American Currents

Publication of the North American Native Fishes Association

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The North American Native Fishes Association

Est. 1972 — John Bondhus, founder

Mission: The North American Native Fishes Association (NANFA) is dedicated to the appreciation, study and conservation of the continent's native fishes. NANFA is a 501(c)(3) not-for-profit, tax-exempt corporation chartered in the State of Maryland. The purposes of the organization are: • to increase and disseminate knowledge about native North American fishes; • to promote practical programs for their conservation and the protection/restoration of their natural habitats; • to advance the educational, scientific and conservation benefits of captive maintenance and husbandry; • to encourage the legal, environmentally responsible collection of native fishes for private aquaria as a valid use of a natural resource; and • to provide a forum for fellowship and camaraderie among its members.

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American Currents

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Volume 46 Number 3 Summer (July) 2021

Konrad Schmidt and Fritz Rohde, *Co-Editors*

Bruce Bauer, Bruce Lilyea, Olaf Nelson, John Olson, and Tom Watson, *Associate Editors*
Olaf Nelson, *Design and Layout Editor*
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NANFA News

MEMBERS, EVENTS, ACCOMPLISHMENTS, AND ADMINISTRIVIA

This NANFA News will be the last edited by Konrad Schmidt. Please send future news items to Bob Hrabik, who will be taking the reins for the fall issue (Thank you, Bob!). His email is roberthrabik@gmail.com.

2021 NANFA CONVENTION/GET TOGETHER

The 2020 NANFA Convention that was to be held in South Carolina in March was cancelled because of the COVID-19 pandemic. But with the number of COVID cases in a sharp decline and with the increasing number of vaccinations, the NANFA Board of Directors and South Carolina host and rep Dustin Smith have tentatively agreed to have an event based in Columbia, SC the weekend of October 7-10. We are in the very early stages of putting this together and will provide more information as soon as we finalize things. The webpage should be updated by the time you receive *American Currents* and it will mostly follow the format laid out for the 2020 convention with same meeting venue, same hotel, most of the same speakers, and same field trips, but different t-shirt. Go to http://www.nanfa.org/convention/2020.shtml to see the details. Hope to see you there for some long-needed fishy fellowship.

2022 CONVENTION WILL CELEBRATE AS NANFA MARKS HALF A CENTURY

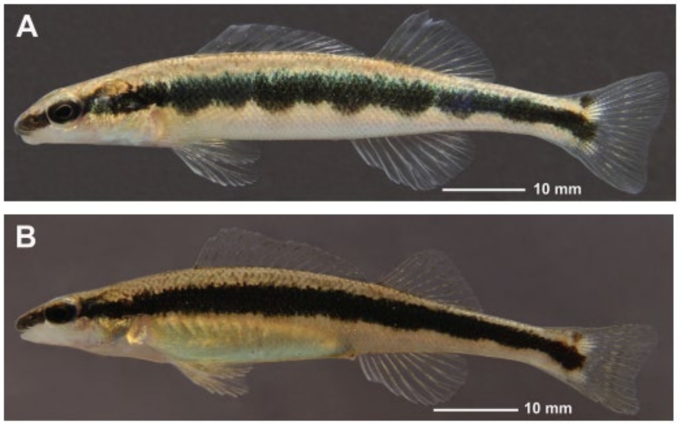
In 1972, John Bondhus (Monticello, Minnesota) founded the North American Native Fishes Association. Ray Katula (Onalaska, Wisconsin) was 14 when he met John and was one of the first members to join NANFA. Ray later became president and in 1993 hosted the only annual meeting held in Minnesota. This is where Jenny Kruckenberg (Inver Grove Heights, Minnesota) attended her first meeting; she is now a NANFA regional representative. Both Ray and Jenny very much want to bring NANFA home for its 50th anniversary and are willing and eager to jump in as hosts. Minnesota cannot compete with the ichthyofauna found in the southeastern states or the Ozarks but does have a unique cross-section of species. This is attributable to Minnesota covering three major basins: Hudson Bay, Great Lakes and Mississippi River. See the Minnesota checklist at http://www.nanfa.org/ac/how-many-minnesota-fishes.pdf. The city of Winona in southeastern Minnesota, is being considered for the location the weekend of June 9-12. This part of the state lays claim to the state's greatest species diversity, with 123 fishes inhabiting the Mississippi River and its tributaries.

Since this will be NANFA's golden anniversary, some species being considered for the convention's T-shirts are Gilt Darter *Percina evides,* Golden Shiner *Notemigonus crysoleucas,* Golden Redhorse *Moxostoma erythrurum,* and Goldeye *Hiodon alosoides.*

Please remember: We always welcome and need submissions of news items, articles, photographs and more.

NEW SPECIES OF BRIDLE DARTER NAMED AFTER BUD AND MARY FREEMAN

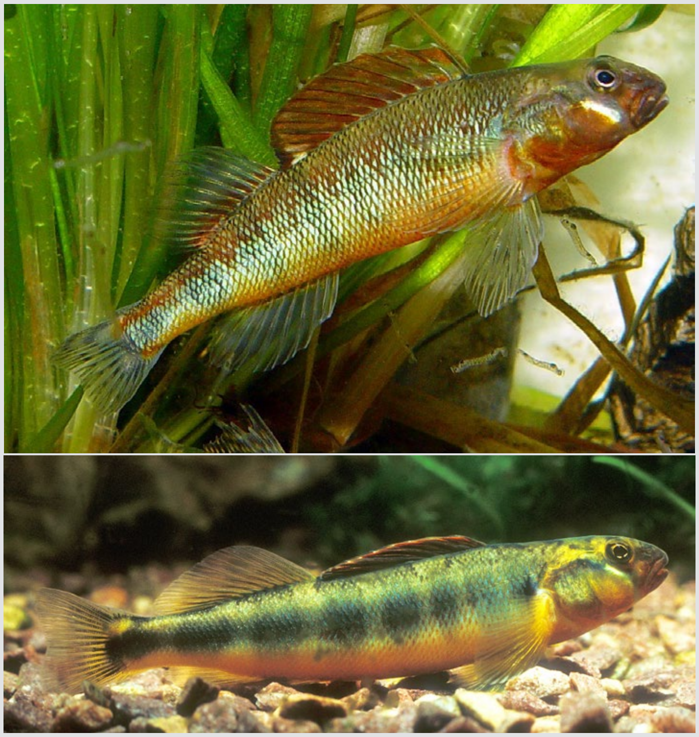
Several NANFA members and friends recently honored colleagues Mary and Bud Freeman for being the namesake for the newly described Etowah Bridle Darter *Percina freemanorum* (see Near et al. 2021. Bulletin of the Peabody Natural History Museum 62(1)). This species is endemic to the Etowah River system in Georgia. The Freemans were selected by Near et al. for the patronymic name of the Etowah Bridle Darter (*freemanorum* literally translates as "of the Freemans") for their many substantial contributions to the study of fishes of the southeastern United States. In particular, their work has shed light on, and significantly aided in, the conservation of the richly biodiverse Etowah River system.



***Percina freemanorum* male (top) and female (bottom). (Photo by Georgia DNR)**

Mary and Bud Freeman. (Photo by UGA)

HOW ABOUT ADDING A *"CF."* FISH IN FOCUS SECTION TO AMERICAN CURRENTS?



Male Gilt Darters: North Carolina, eastern clade (top) and Minnesota, western clade (bottom). (Photos by Konrad Schmidt)

Ichthyologists have long found variations in the same species across their ranges. Meristic and morphological analyses often support these findings, but that is not the final say a certain population is merely variation, subspecies, or possibly a new species hiding in plain sight. When this occurs, the abbreviation *"cf."* may be assigned to the species' scientific name to flag a population. *Cf.* is short for the Latin word *confer* meaning compare. Continued advancement and refinement in genetic analyses are slowly providing answers. However, funding for this kind of research is scarce and suspected new species gather dust waiting for genetically-focused grad students to come along looking for thesis projects. A suggested candidate for the *cf.* Fish in Focus premiere could be the Gilt Darter *Percina evides*. Research by Thomas Near et al 2011 (https://academic.oup.com/sysbio/article/60/5/565/1644769) referred to the two western clades (i.e., Ozarks and Minnesota-Wisconsin) as Western Gilt Darters *P. cf. evides*. Jay Hatch (University of Minnesota) did his doctoral thesis on the life history of Gilt Darters in the St. Croix River basin (Minnesota and Wisconsin). Based on additional research from different sources, he now refers to this population as the Western Gilt Darter *P.* sp. *cf. evides*. There is a motherlode of populations referred to as *"cf."* assuring there will be no shortage of material to use for this section. Many NANFA members have also referred to "odd balls" of the same species when collecting in different states and drainages. Let's bring attention to these unique populations and hopefully spark interest in future research that may find new species, or the very least, learn how much populations differ across their ranges.

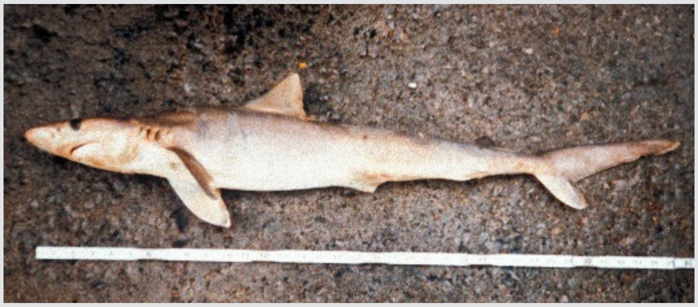
NANFA CONSERVATION RESEARCH GRANT FOR 2021 AWARDED

The grant committee, comprised of Michael Wolfe, Derek Wheaton, and Bruce Lilyea, has selected the application from Jessica Diallo, a Masters student at the University of Washington. The research questions for the proposed study are: "(1) Which removal methods are most effective in reducing Green Sunfish local abundance and spatial extent? (2) How do native fish populations respond to invasive removal in abundance and individual growth? (3) Does food web structure recover to its pre-invasion state after invasive removal?" Excerpts from Jessica's proposal:

> Invasive species are a leading cause of fish species imperilment in North America, with impacts manifested across multiple levels of ecological organization from individuals to ecosystems. The nexus of endemic fish species and invasive impacts is apparent in dryland rivers of the American Southwest. Recent decades have witnessed increasing efforts to control or eradicate invasive fish in attempts to restore freshwater ecosystems, however, results have been mixed and many have failed to achieve desired outcomes. Primary reasons for variable success of removal programs include uncertain species interactions, differing environmental conditions, and wide-ranging removal practices. As a consequence, future management efforts would benefit from research that explicitly evaluates removal effectiveness with respect to these contributing factors, especially given the high cost of removal programs. In recent decades, multiple control and eradication efforts have been conducted in the Lower Colorado River Basin, many led by the Arizona Game and Fish Department (AZGFD). Despite best intentions, these programs have not always resulted in measurable success and most were not designed with a robust experimental design and clear measures of success to inform future removals. This research project leverages a new collaboration with the AZGFD to quantify ecological recovery at the community, population, and individual levels across a spectrum of Green Sunfish and Fathead Minnow removals in Ash Creek, a tributary of the Bill Williams River, Arizona.
>
> Benefits of this project will be seen immediately as well as in years to come. In initiating an invasive fish removal project alongside the AZGFD, we will relieve native fish populations of a major threat so their populations can begin to recover. The long-term viability of native species in the Lower Colorado River Basin is dependent on successful restoration projects. The Bill Williams River watershed is particularly relevant to native fish conservation as a stronghold for Roundtail Chub, a candidate for federal listing8 and a species of conservation concern in Arizona. Our research will also inform invasive fish removal efforts in rivers throughout North America. By understanding community, population, and individual responses to invasive fish removal, our research will improve management practices and lead to healthier native fish populations.

1995 REPORT OF A SHARK IN A POWER PLANT RETURN FLOW CHANNEL AT RUSH ISLAND, MISSISSIPPI RIVER, MISSOURI, DETERMINED TO BE A HOAX

Robert A. Hrabik



Sharpnose (*not* Bull) Shark found in 1995.

Editor's Note: *Bob is putting the final wraps on his Fishes of Missouri. During his revising of the book's species account for Bull Shark* Carcharhinus leucas, *suspicions were raised about this record. Sherlock Hrabik started digging and proved quite conclusively it was indeed fake news.*

On August 26, 1995, Missouri Department of Conservation fisheries biologist Mike Fuhr received a phone call regarding the discovery of a shark found "impinged" on the intake screen(s) of an AmerenUE power plant at Rush Island, Mississippi River (approximate RM 140.3), Jefferson County, Missouri.

Fuhr proceeded to meet with power plant staff, measure the fish, and take photographs of the specimen (photo above). The story as to how this fish was discovered was apparently not documented (by memorandum) by Fuhr. However, in one filed memorandum, Fuhr explained to power plant staff that a Bull Shark *Carcharhinus leucas* previously was captured from the Mississippi River (that capture was in 1937, and a detailed accounting of the collection appeared in a scientific journal in 1977).

Because Fuhr had shared with power plant staff that a Bull Shark was captured from the Mississippi River (1937), it has, over the years, been assumed that the 1995 capture was another Bull Shark.

In 1995, AmerenUE biologist Frank Putz had contacted Dr. Thomas Keevin (St. Louis Army Corps of Engineers) alerting him of the discovery. Putz suggested to Keevin that the two of them co-author a manuscript describing the discovery. After initiating the project, Putz contacted Keevin and informed him that he thought the incident was a hoax and that he had decided to discontinue the project. It was never known what Putz may have discovered, and apparently the subject was dropped. Putz died in 2013.

When I began gathering data and information on sharks (in general for the family and species accounts and locality data for archiving and mapping), the first item of business was to contact anyone who was still alive that might recall the story of how the 1995 shark was discovered. This eventually led to me to track down Clarence Schewain, who was the person that found the shark. Mr. Schewain, now retired, provided me with much detailed information as to where the fish was found (in a water return channel below the intake screen) and what process it would have had to endure to get where it finally rested.

Because Putz had suggested that the discovery was a hoax, I pressed Schewain on that subject, and he held rather firm that, to his knowledge, it was not. I did learn, however, that Schewain was, and is, quite a fisherman and had spent time fishing in the ocean that same year and knew the identity of several saltwater fishes. During my interview with him, I mentioned that we (in MDC) had been calling this fish a Bull Shark, to which Schewain replied that he "didn't think it was a Bull Shark" and thought it was a common "sand shark." I found it curious that he quickly had a different identification of the specimen. However, the interview seemed rather matter of fact and, at the time, I had no reason not to believe that the shark encounter was a real occurrence.

Recently, I completed the family and species account for the Carcharhinidae and Bull Shark. As I was reading in detail about the identification, taxonomy, and life history of this species, it hit me that Fuhr's photographs did not seem to be consistent with what I had just read and written about Bull Sharks.

Being no expert on sharks, I turned to the only shark expert I know: Dr. Daniel Able of Coastal Carolina University, lead author on a great shark book published in 2020. I suggested to Dr. Able that I was having reservations about the identity of this shark, and I provided him with written communiques and Fuhr's photographs.

Dr. Able replied on that the specimen was "definitely NOT a Bull Shark." He elaborated further: "The second dorsal fin is black, which is characteristic of Sharpnose Sharks (genus *Rhizoprinododon*). The slim body and pointed snout are not Bull Shark characteristics either but point to Sharpnose Shark. Likely [this specimen was] transported from the coast and discarded."

Therefore, I consider this record invalid because, in all probability, this fish was "planted" at the Rush Island power plant and was part of an elaborate hoax. The written communiques regarding the 1995 specimen, as well as slides of the specimen, were filed in the St. Louis Regional Office. Recently, those files and the slides have been archived by both myself and in the MDC Central Office in Jefferson City.

2021 MINNESOTA DARTER HUNTS GETS BLOGGED.

Amazonas editor Matt Pedersen joined a recent Darter Hunt hosted by Jenny Kruckenberg and shared his family's experience on the magazine's blog. The first hunt of the day was at Square Lake (Washington County) for Iowa Darters *Etheostoma exile.* The group also found Johnny Darters *E. nigrum,* Banded Killifish *Fundulus diaphanus,* Blackchin Shiners *Notropis heterodon,* Blacknose Shiners *N. heterolepis,* Bluntnose Minnows *Pimephales notatus,* Spotfin Shiners *Cyprinella spiloptera,* and Central Mudminnows *Umbra limi.* Konrad Schmidt dip netted over 60 Least Darters *E. microperca* off the fishing pier. The species is listed special concern in Minnesota, and Konrad had translocated Least Darters to the lake in 2014. The second hunt, at Old Mill Stream a few miles away in Marine on St. Croix, turned up nuptial Rainbow Darters *E. caeruleum*. The colorful males never fail to take your breath away!

Matt's blog showcases the day with great photos. Please visit it at https://www.amazonasmagazine.com/mndarterhunt2021.

CONSERVING THE STARHEAD TOPMINNOW *FUNDULUS DISPAR* IN WISCONSIN:

2. CONSERVATION AQUACULTURE

David W. Marshall, John Lyons, Sue Marcquenski, Tim Larson, and Jean Unmuth

This article is Part 2 of a three-part series. Part 1 described the threats to and current status of the state-endangered Starhead Topminnow in Wisconsin and the value of a reintroduction project to increase its distribution. Part 2 covers efforts to culture large numbers of Starhead Topminnows for the reintroduction. Part 3 will summarize results of the reintroduction project and conservation implications. Here, in Part 2, we also relate the three important lessons we learned from raising Starhead Topminnows in a semi-wild pond: 1. Expect the unexpected. 2. Forget any notions of laissez faire pond management. 3. Monitor often and adjust as needed.

INTRODUCTION

Conservation aquaculture is defined as the use of fish rearing to recover endangered or imperiled fish populations (Anders 1998, Ireland et al. 2002). Our discussions about potentially using conservation aquaculture techniques to protect the Wisconsin state-endangered Starhead Topminnow began in 2012. We had realized that the ongoing loss of this topminnow's primary habitat along the Lower Wisconsin State Riverway would continue since the core of the problem is intransigent agricultural policies and practices that allow nitrate pollution. In 2013, the Lake Ripley Management District in southern Wisconsin had sponsored a state grant to study conservation aquaculture as a way to restore nongame fishes (aka "dickey fishes") in their lake. That document (*Feasibility of Restoring Nongame Fish Species in Lake Ripley, Jefferson County, Wisconsin*) provided additional justification for our first-of-its-kind project to re-establish a rare nongame fish species in Wisconsin.

As we mentioned in Part 1, the Starhead Topminnow recovery effort includes introducing and expanding the fish's population beyond the zone of pollution and above the Prairie du Sac dam, which was part of the species' historic range. To have enough fish, we needed to raise large numbers via conservation aquaculture. We already had a site identified for this—an isolated, fishless pond on Dave Marshall and Wendy Weisensel's rural property—but we needed funds to raise and stock the fish. The project became a reality in 2018 thanks to a grant from the Prairie du Sac Dam Aquatic Resources Enhancement Fund, established by Alliant Energy as part of this utility's hydroelectric dam licensing under Section 408 of the Federal Energy Regulatory Commission. Because the Starhead Topminnow is a state-endangered species, to begin conservation aquaculture we also needed to obtain an Endangered Species Collection Permit from the Wisconsin Department of Natural Resources (WDNR) and a Class III Fish Farm License from the Wisconsin Department of Agriculture, Trade and Consumer Protection.

Photos by David Marshall unless otherwise indicated.

John Lyons was a statewide Fisheries Research Scientist and Supervisor for WDNR and is now Curator of Fishes at the University of Wisconsin Zoological Museum in Madison. Dave Marshall was a Water Quality Biologist for WDNR covering southwestern Wisconsin and the Lower Wisconsin River, as was Jean Unmuth. Sue Marcquenski was the statewide WDNR Fish Health Specialist, and Tim Larson was the WDNR Fisheries Manager for Sauk and Columbia counties, including the Wisconsin River above the Prairie du Sac Dam.

THE POND

Our rearing pond, which we now call Topminnow Pond (Figures 1 and 2), was originally constructed in 1995 for wildlife habitat. It is located within a grassland bird conservancy known as Big Hill

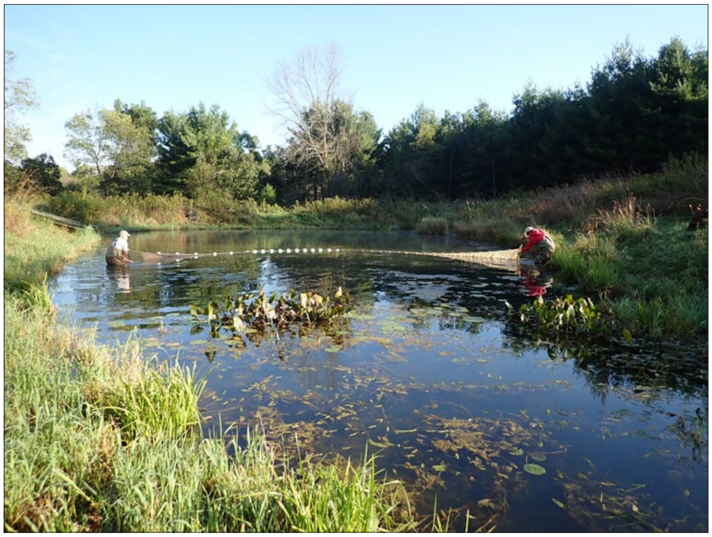


Figure 1. September 2018 Starhead topminnow collection in Topminnow Pond for stocking above the Prairie du Sac dam. Tim Larson and Dave Marshall used the small mesh seine to concentrate the fish at one end of the pond for dip netting. View facing north. (Photo by Wendy K. Weisensel)

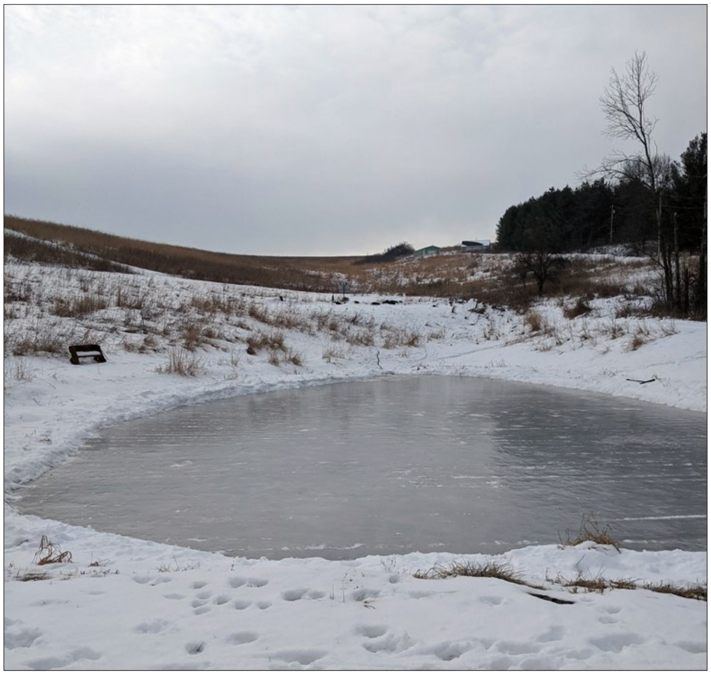


Figure 2. Topminnow Pond January 2021, facing south.

Savanna in Iowa County. This small pond, only 0.1 acre in area with a maximum depth of 6 feet, was constructed as an embankment-excavation pond. Its only water source was infrequent surface runoff from the pond's 22-acre watershed of native grassland. The pond is productive given the relatively large watershed to pond ratio (220:1) but no significant nutrient sources exist. This landlocked pond did not require permits since it was constructed in a low-lying hay field as opposed to a floodplain or wetland. Floating Leaf Pondweeds *Potamogeton natans* and *P. nodosus* cover most of the pond surface during the growing season. Other plants include White Waterlily *Nymphaea odorata, Spatterdock Nuphar advena* and Pickerel Weed *Pontederia cordata. Low densities of Muskgrass Chara* and the non-native Eurasian Watermilfoil *Myriophyllum spicatum* grow around the perimeter. The pond supports diverse planktonic and benthic invertebrates, along with American Toads *Anaxyrus americanus*, Green Frogs *Lithobates clamitans*, Pickerel Frogs *L. palustris*, Spring Peepers *Pseudacris crucifer*, Chorus Frogs *P. triseriata*, Eastern Gray Treefrogs *Hyla versicolor*, Cope's Gray Treefrogs (*H. chrysoscelis*), Snapping Turtles *Chelydra serpentina*, occasional Painted Turtles *Chrysemys picta*, and Common Water Snakes *Nerodia sipedon*.

We thought this wildlife pond could be suitable for raising Starhead Topminnows for three reasons. First, we had experience raising the closely-related Blackstripe Topminnow *F. notatus* in the pond. Five adults, three males and two females, were introduced into the pond over a decade ago in what could be called a whim, certainly not a controlled experiment. The fish were collected as part of a routine WDNR survey in the spring of that year and were originally destined for an aquarium. By the end of the summer more than 100 Blackstripe Topminnows were easily seen swimming at the pond surface. They survived the winter and became far more numerous by the end of the next growing season. The topminnows were so abundant that the water surface boiled when observers approached the pond. However, by the end of the second winter all were found dead. The pond was not aerated or managed in any way. Anoxic winterkill was the likely cause. Since the sole source of water for the pond was the 22 acres of grassland, where surface runoff is often low, the combination of snow, ice, and low water likely contributed to anoxia.

Second, we were encouraged by NANFA member P. T. Johnson's (2012 *American Currents* 37:4–10) article and his reported success raising Starhead Topminnows in an artificial pond. Third and most importantly, our pond displayed many of the environmental characteristics of the Lower Wisconsin State Riverway oxbow lakes, where Starhead Topminnows occur naturally. What the pond lacked was groundwater input. Nearly all areas where we have found good Starhead Topminnow populations receive water from springs or groundwater seeps. To provide this important environmental feature, a contractor drilled a 160-foot well and a pump installer put in a DC solar well pump system to discharge calcareous groundwater into the pond. The pump system supplies the pond with groundwater to compensate for the limited runoff the pond typically receives. The 255-watt solar panel system does not include batteries and only pumps well water during daylight hours. The pump can deliver about six gallons of groundwater per minute but the rate declines under cloudy skies. The pond's groundwater source is chemically similar to the Lower Wisconsin River aquifer, though nitrate levels are much lower (Table 1).

We describe the pond as semi-wild since the fish receive no artificial food. The pond has natural predators including birds, reptiles and aquatic insects: Belastomidae – *Belastoma* and *Lethocerus grisea,* (Giant Water Bugs), and Notonectidae (backswimmers). Introduced Starhead Topminnows are the only fish in the pond.

YEAR 1

Our goal in Year 1 was to collect enough Starhead Topminnows from the Lower Wisconsin River in the spring to establish a ge-

Table 1. Pond and Well water quality data collected during the project. Also presented are recent data from one of the Lower Wisconsin River (LWR) polluted oxbow lakes (Jones Slough) for comparison. ND indicates no data.

Location	Dissolved oxygen (mg/l)	pH	Alkalinity (mg/l)	Nitrate NO$_3$-N (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Total Phosphorus (mg/l)	Turbidity (NTU)	Conductivity (uS/cm)
Pond	0.9 – 19.5	7.1 – 8.2	144 - 300	0 – 0.4	0.48 – 0.52	0.028 – 0.379	2.2 – 5.6	235 - 430
Well	7	8	300	1.3 – 2.2	ND	0.015	0	559
Jones Slough LRW groundwater	1.5 – 11.8	6.9 -8.1	ND	17.4 mean	0.4 – 1.3	0.11 mean	2.5 mean	422 mean

netically diverse brood stock in the pond, then propagate topminnows the entire summer and stock all of them above the Prairie du Sac Dam by mid-October. We then planned to repeat the process in following years. In May and June 2018, we collected 119 Starhead Topminnows from seven different oxbows and sloughs along the river. Our brood stock consisted of 61 females, 44 males (1.4:1 ratio) and 14 immature fish. Taylor and Burr (1997) reported as part of their study of Illinois Starhead Topminnows that the female to male ratio was 1.5:1. We used long-handled small-mesh dip nets that are very effective for collecting Starhead Topminnows at the surface. Dip nets are also much easier to haul around than DC electroshocking gear in the plant-filled soft-bottom sloughs. We learned years ago to avoid seines that often result in fish mortalities in weedy environments. Starhead Topminnows and other small fishes are difficult to separate from dense clumps of plants in the seine and can suffocate. We also occasionally lost some fish that were stung by water bugs (Hemiptera) and we have also personally experienced that painful sting.

Collected fish were acclimated and transported in pond water that we brought to the river in coolers to minimize chances of introducing river "hitchhikers" into the pond. Once the topminnows were placed in the coolers, we added battery-powered aeration. By the time all of the brood stock were released into the pond, on June 5, 2018, the water column was teeming with large-bodied *Daphnia*, copepods, and phantom midge larvae (*Chaoborus*), all of which would be potential food for Starhead Topminnows. Backswimmers, potential predators, were also numerous in the pond. After the initial fish releases, we didn't see any topminnows until June 20 other than an occasional adult near shore. Starhead Topminnows are clutch spawners, releasing about 20 eggs per clutch several times from spring to fall. Females lay their eggs on submergent vegetation and fry hatch about 9–11 days later at water temps ca. 25 C. By June 27, we started seeing fry close to shore.

We were elated to see Starhead fry emerge in the pond, but that enthusiasm quickly turned to concern when dissolved oxygen levels began dropping daily. Very low concentrations persisted for most of the summer. We responded by setting up several 100-watt solar panels and deep-cycle batteries for continuous small-scale DC and AC inverter powered aeration (< 10 watts). However, the units were not powerful enough to increase dissolved oxygen levels beyond the immediate area of the air stones. Interestingly, we observed that the topminnows were not at all attracted to the aeration and remained dispersed across the pond even when dissolved oxygen levels dropped below 2 mg/l, and occasionally as low as 1.1 mg/l. The topminnow response to low dissolved oxygen wasn't a complete surprise since we routinely find Starheads in sloughs containing very low dissolved oxygen. Fundulidae species survival in low dissolved oxygen environments had been reported elsewhere (Killgore and Hoover 2001, Turko and Wright 2015).

Suppressed dissolved oxygen as a response to dense aquatic plant canopies is well-documented (Unmuth et al. 2000, Frodge et al. 1990). Topminnow Pond is loaded with plants but what took us by surprise was the extended periods of very low oxygen levels. More importantly, we were concerned that these conditions would be harmful to the Starhead Topminnow eggs and fry, which may be more vulnerable than adults.

Beginning in early July, we used a long-handled weed cutter to remove dense pondweeds from the middle of the pond. We hoped to expand open water to increase atmospheric gas exchange, water circulation and algal photosynthesis. Instead, our data demonstrated that re-aeration was very slow (Figure 3). Wind-driven water circulation is minimal because the pond sits in a protected valley. Phytoplankton and filamentous algae did not increase significantly after the macrophyte harvesting, perhaps due to nutrient competition and chemicals that some rooted plants release (Lurling et al. 2006).

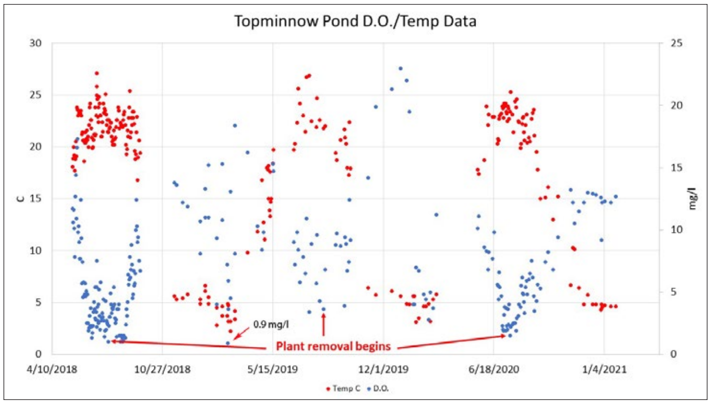


Figure 3. Pond Dissolved Oxygen (blue dots) and Temperature (red dots) Data.

During our first aquatic plant harvest, we carefully inspected stems and leaves to ensure that we weren't also removing fish eggs. We did not see any eggs on pondweeds removed from the middle of the pond, but we did find fish eggs attached to milfoil leaflets in the nearshore area. The plants with eggs were placed in a bucket and later in a small aquarium. In spite of atmospheric exposure up to 10 minutes before being placed in the bucket, Starhead eggs hatched in the aquarium several days later (Figures 4 and 5). The newly hatched fry in the aquarium were attracted to ground commercial fish food, but whether they ate any was unclear. After approximately one week, we returned the fry to the pond where numerous other tiny fish were swimming in the nearshore areas.

We also observed numerous backswimmers and Starhead Topminnow young-of-year (YOY) constantly chase one another, but we didn't notice casualties. The opposite occurred when dip-netted Starheads were placed in stocking buckets containing

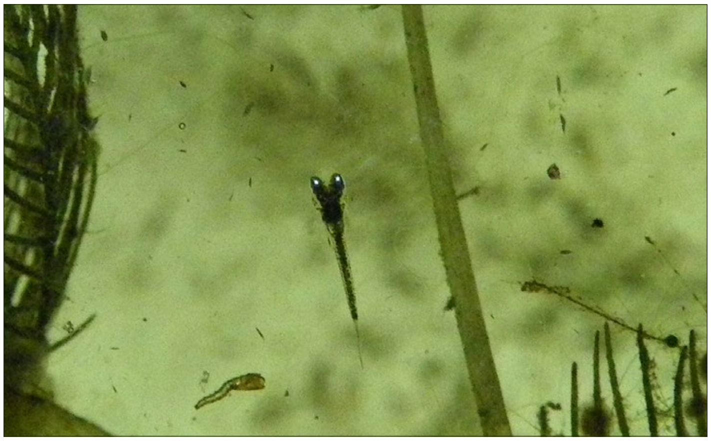


Figure 4. Newly hatched Starhead Topminnow fry that hatched from eggs attached to Eurasian watermilfoil stems that were removed from the pond and placed in an aquarium.

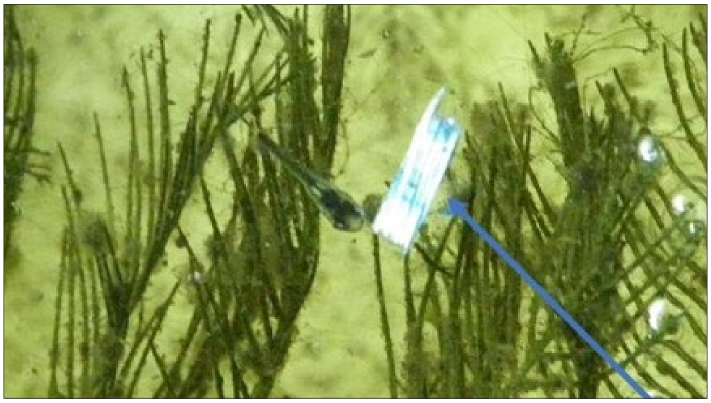


Figure 5. A nearly week old Starhead Topminnow fry next to a 5 mm float for scale.

backswimmers that had been unintentionally collected during the capture process. When confined in the bucket, the backswimmers could easily catch and kill the small Starhead Topminnows. NANFA member Charles Nunziata (2017 *American Currents* 42: 5–9) described the importance of careful and limited handling of Fundulidae species. He mentioned collecting the fish can be traumatic and expose them to infections. Respectful handling of the fish was always our priority, but we also learned to remove backswimmers immediately from the buckets of Starhead Topminnows that were destined to be stocked in the Wisconsin River.

CLIMATE CHANGES EVERYTHING

Pond management included daily dissolved oxygen monitoring, aeration when needed, daily well pumping, and aquatic plant harvesting. This level of management was possible because Dave Marshall lives on the pond property. Beyond routine pond management, our original goal was to dewater the pond to remove all of the cultured fish and stock them by the end of the 2018, then restock the empty pond with wild fish the following spring. But thanks to the unexpected, we had to alter our plan by late summer due to a prolonged wet period. Continuous river flooding through October 2018 reduced stocking opportunities. And for the first time since the pond was constructed in 1995, late summer runoff water exceeded the pond capacity and led to a spillover. A metal screen had been installed in front of the outlet culvert to deter possible fish escape. As the pond reached its capacity, we added a small-mesh seine for additional outlet screening. On the morning after a September 5th storm, 73 fish somehow escaped through the culvert and ended up with nowhere to swim below the landlocked pond. We were able to save 47 fish found flopping in the grass and return them to the pond. The other 26 were found dead and were preserved for necropsy. During the storm, a 12-foot jon boat sat at the pond edge with its drain plug removed. After the pond level reached the drain, dozens of Starheads entered the boat. Perhaps these escape behaviors mimicked the migrations that occur along the Lower Wisconsin River during high river stages?

Throughout that fall we were able to keep all the fish in the pond by securely overlapping the small-mesh seine around the outlet culvert. As an additional response to the unexpected, we set up a jury-rigged system to capture fish alive in case of escape (Figure 6). From the initial 119 Starhead Topminnows introduced into the pond, we were able to stock 1,164 mostly YOY at two sites above the Prairie du Sac dam in 2018 (Figure 7). However, hundreds of topminnows remained in the pond that we were unable to stock in 2018. The next challenge was keeping them alive over the winter, something we hadn't planned for.

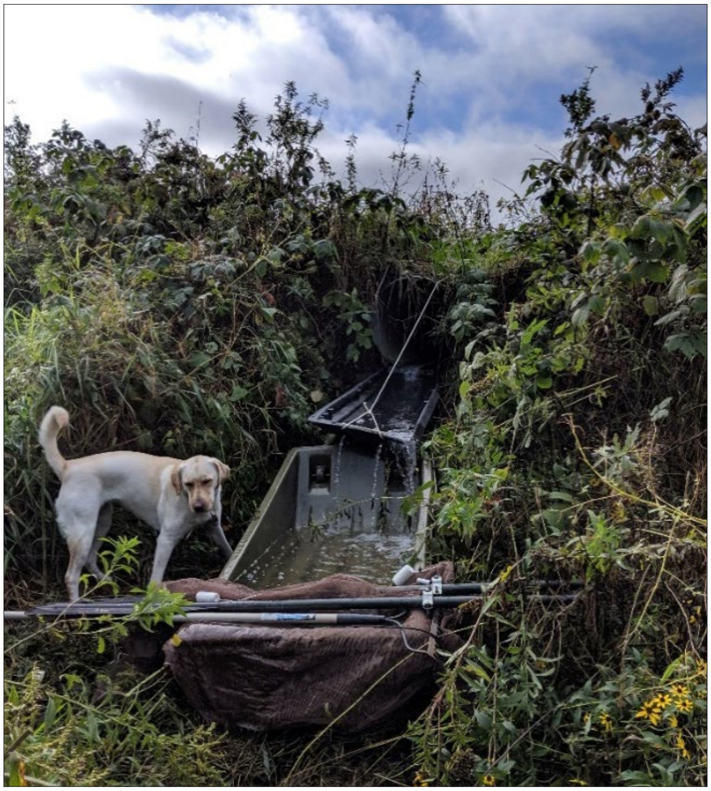


Figure 6. Jury-rigged system set up to catch escaping Starhead Topminnows, with Hatchery Manager Biscuit on duty.

YEARS 2 AND 3

Year 2, 2019, began with managing water supply and maintaining adequate dissolved oxygen levels in the pond over the winter. A few water-supply freeze-ups occurred in the shallowly buried pipe between the well's anti-siphon chamber (an air space to prevent back-

Figure 7. Starhead topminnows in transport cooler for stocking. (Photo by Wendy K. Weisensel)

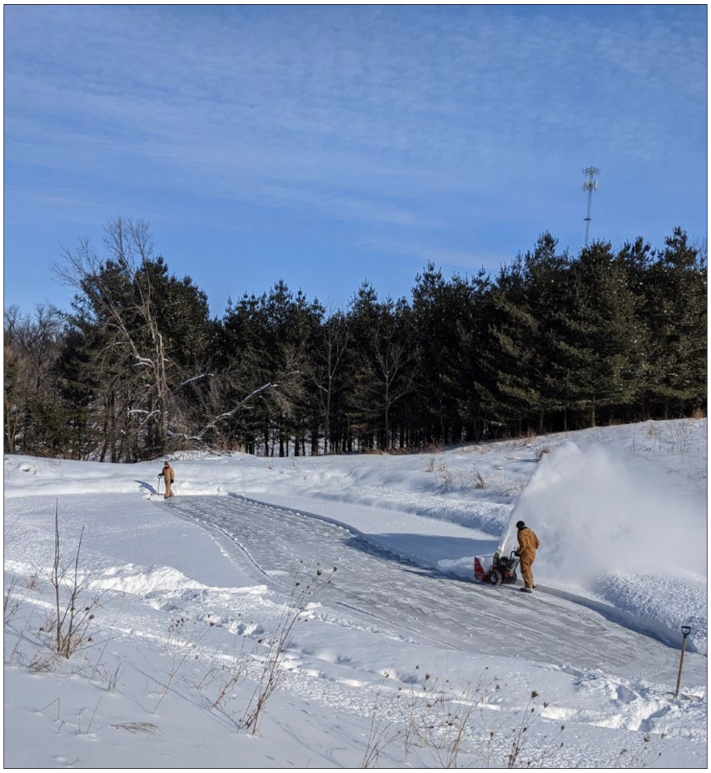


Figure 8. We had to hire for snow removal after heavy snowstorms. This 9-inch snowstorm was way too much work for us senior-citizen biologists.

flow to the well) and pond. The buried pipe was replaced with an overland pipe that can be detached and thawed if ice blocks water flow. Clearing snow off the pond was a priority to ensure light penetration and photosynthetic oxygen production (Figure 8). After one storm dumped 10 inches of snow on the pond, dissolved oxygen declined rapidly to 0.9 mg/l (Figure 3). The heavy snow also placed pressure on the ice. As holes were drilled for aeration, water rushed onto the ice and melted snow. We moved air stones around daily to distribute aeration and allow the open water to quickly freeze and create clear ice. The combination of snow melt and patches of clear ice, as opposed to cloudy white ice, increased light penetration, which then encouraged plant photosynthesis and increased dissolved oxygen (Prowse and Stephenson 1986). We only aerated when low dissolved oxygen threatened because continuous aeration in subzero conditions could quickly cool this shallow pond adding to ice thickness and reduced living space.

Ice-out occurred March 27, 2019 and by March 29 Starhead Topminnows were observed around the pond perimeter. Fish remained submerged and surface schooling did not begin until water temperatures reached 16.8 C (62.2 F) (Table 2). By early May, hundreds of Starhead Topminnows of varying sizes swam across the pond surface. We were able to stock 865 in the spring and another 858 in late summer. After the spring stocking, we added 15 more adults from the Lower Wisconsin State Riverway to increase genetic diversity and avoid genetic drift. We had intended to collect more fish, but spring flooding dispersed them, and we didn't find many.

We noticed one significant change in 2019 from previous years when the pond was fishless. The normally abundant zooplankton and phantom midge larvae had disappeared. We suspected that the Starhead Topminnows represented a form of biomanipulation that reduced the large-bodied zooplankton. This loss of zooplankton did not appear to affect Starhead growth and survival, perhaps due to the topminnow's omnivorous diet (Becker 1983). On top of that, we saw fewer backswimmers in the pond as well.

Table 2. Notes on Starhead Topminnow behavior in Topminnow Pond

Starhead Topminnow surface schooling declines significantly during spawning.
Spring surface schooling begins when water temperatures reach about 62 degrees F.
Starhead Topminnows remained below the surface and inactive at night. The fish were not attracted to a night light. Only giant water bugs swarmed under a light hanging over the pond.
Giant water bugs and backswimmers pose a hazard if allowed in the same container with Starhead Topminnows.
Starheads were not attracted to aeration even when dissolved oxygen levels dropped to 1 ppm.
Seining is not recommended for Starhead Topminnow collection since they can be lost in dense clumps of plants and suffocate.
The female to male adult sex ratio (1.56:1) in Topminnow Pond was very similar to published data.

During the 2019 late summer stocking, we tried to collect mostly adults and larger juveniles. We thought that adult fish chances for survival in the wild were greater than the much smaller YOY fish that can be more vulnerable to predation. Smaller fish were certainly vulnerable to netting and far easier to capture than adults. We preferred to collect adults, but they avoided us by swimming to the middle of the pond as soon as we approached the bank. Their avoidance behavior reduced the total numbers of fish we hoped to stock in late summer 2019 and 2020.

Given our success with overwinter survival in 2018, we decided to overwinter YOY fish in the pond the next two years to increase growth and improve survival. We weren't confident about stocking the very small fish into new environments full of fish predators. Our surveys of Lower Wisconsin River Starhead Topminnows suggested annual population pulses with maximum numbers typically occurring in late summers following multiple clutches. We always observed far lower numbers each spring, suggesting predation or other forms of mortality over the winter.

We continued to remove rooted plants from the middle of the pond each year even though the environmental benefits remained dubious, given the Starhead Topminnow's tolerance of low dissolved oxygen. We felt that removing plants during the summer could reduce under-ice decomposition and oxygen depletion during the winter.

In Year 3, 2020, pond propagation continued, and we removed and stocked another 940 fish. We followed Covid-19 health precautions by wearing masks and maintaining social distancing. Those masks made it a lot harder to drink beer after we finished our work, but we managed. We tallied adults by sex and determined that the female to male ratio of stocked adults was 1.56:1, very close to the Taylor and Burr (1997) reported value. By the end of Year 3 we had stocked a total of 3,579 fish above the Prairie du Sac dam.

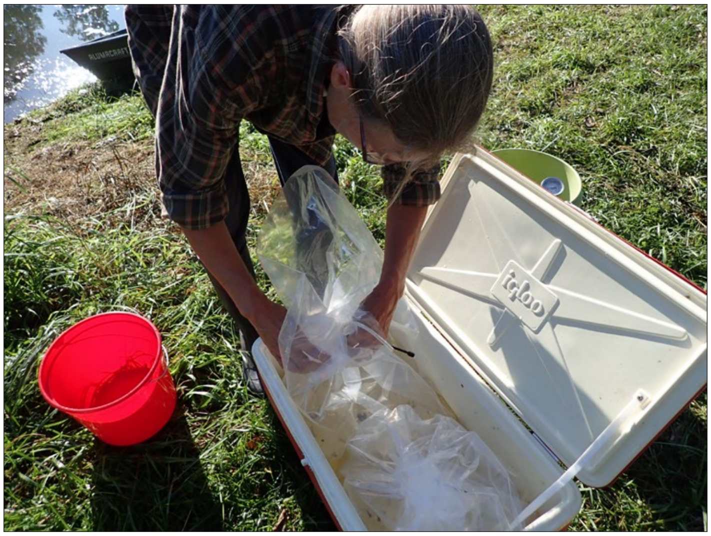


Figure 9. Sue Marcquenski preparing aerated coolers and fry bags for Starhead Topminnow stocking above the Prairie du Sac dam. (Photo by Wendy K. Weisensel)

FISH HEALTH CERTIFICATE

As part of the Wisconsin Fish Farm License, a qualified fish health inspector must certify that fish stocked from hatcheries into the wild are healthy and do not pose a disease threat to other wild fish populations. Fortunately, our team includes a qualified fish disease specialist, Sue Marcquenski (Figure 9). Sue really loves this stuff. Who else has a Pirate Perch *Aphrododerus sayanus* liver parasite named after them (*Henneguya marcquenskiae*)? In addition to conducting annual health inspections for fish in the pond, Sue was able to perform necropsies on the few fish lost during stocking operations and the fish that died as part of the September 2018 pond overflow event. The fish lost during stocking events amounted to less than 1% of the total number of fish stocked.

As part of the health certification, live fish as well as preserved specimens were closely examined. Three annual health certificates were issued from 2018 through 2020 and each one stated that no signs of contagious or infectious disease were observed in a 60-fish sample from the pond. Using standard necropsy protocols for the fish that died due to flooding or during release gave us the opportunity to learn more about the anatomy and physiology of this state-endangered species. Fish were preserved in 10% formalin or frozen prior to necropsy. With technical help from the Wisconsin Veterinary Diagnostic Lab, preserved tissues were prepared for histopathology. This allowed us to examine internal organs at the cellular level and evaluate indicators of health such as gill quality, liver condition, ovary and testes development, amount of body fat, and presence of food in the gastrointestinal tract. The gills were generally parasite-free but were hyperplastic in some of the fish, with filament clubbing evident in some of the fish that died at the release sites. This gill pathology can occur when fish are exposed to very low dissolved oxygen levels or other water quality stresses. However, we don't know for sure what specifically caused this gill pathology in some of the Topminnow Pond Starheads. The species evolved to tolerate low dissolved oxygen and no wild fish gills were examined for comparison. Other notes of interest included degenerating livers in old adults and an astonishing observation of egg maturation in YOY fish as small as 22 mm. The frozen fish we preserved gave us the chance to learn more about growth rates, feeding activity, general gill quality, sex ratios, and fin quality.

YEAR 4 – 2021

The last year of the Starhead Topminnow conservation aquaculture program is underway. So far this winter the pond dissolved oxygen has been sustained near saturation and the ice has been mostly free of snow. After a recent seven-inch snowstorm, the dissolved oxygen dropped from 12.6 mg/l to 9.2 mg/l in just one day. The snow was removed right after the storm that evening and dissolved oxygen rebounded to 12.2 mg/l in less than 24 hours. We plan to stock all Starhead Topminnows from the pond this spring and conduct surveys to determine if we will meet our goal of establishing a population of state endangered Starhead Topminnows above the Prairie du Sac dam. Part 3 will present these findings.

ACKNOWLEDGMENTS

We thank the Prairie du Sac Dam Aquatic Resources Enhancement Fund, Friends of the Lower Wisconsin Riverway (FLOW) and the Natural Resources Foundation of Wisconsin for funding and supporting this project. We also thank Lisie Kitchel for her invaluable WDNR Natural Resources Heritage Program guidance and volunteers Merel Black and Wendy K. Weisensel.

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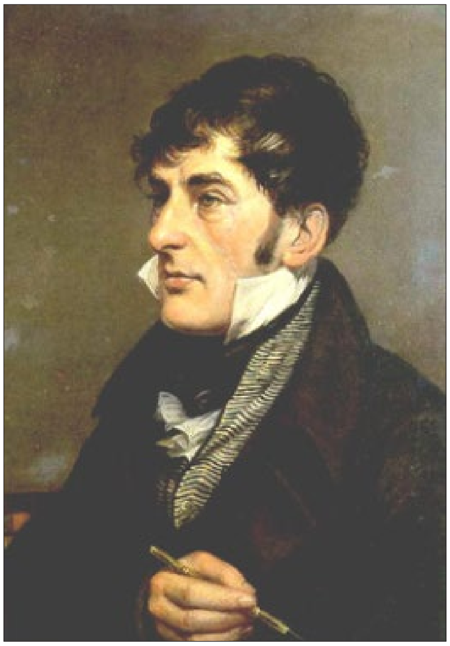
LESUEUR'S LAMPREYS OF 1826:
THE QUEST TO FIND WILKINSON CAVE AND EVIDENCE OF AMERICAN BROOK LAMPREY IN THE ST. FRANCIS RIVER, MISSOURI

Robert A. Hrabik

Oak Ridge, Missouri

Charles Alexander Lesueur (1778–1846; the image of Lesueur is from an 1818 painting by Charles Wilson Peale) was a French explorer, naturalist, and artist. He traveled worldwide collecting and illustrating nature, especially in Australia, Southeast Asia, and North America. In doing so, he described numerous species and secured *type specimens* (the first or designated specimen or group of specimens of a species from which original descriptions are articulated). Fifteen species of fish presently known to exist in Missouri were described by Lesueur (Appendix).



Between 1816 and 1837, Lesueur lived and traveled widely in the United States, particularly in the southeast, including Missouri. From 1826 to 1837, he operated from a cottage in New Harmony, Indiana. This cottage served as his laboratory and was packed with enormous collections. It was from his Indiana abode where this story begins: his travel to southeastern Missouri and description of seven lampreys he collected at a place he called "Wilkinson Cave."

Lesueur, while in New Harmony, decided to begin writing a manuscript on American ichthyology given the short title of *Fishes of North America*. However, he found it difficult to work without interruption in New Harmony because his cottage laboratory was occupied by frequent visitors, many of whom Lesueur invited (Hamy 1968).

Photos by the author unless otherwise indicated.

Bob Hrabik's infatuation with native fishes began while seining for bait with his father on cool fall days in Nebraska. The bait they caught was kept alive overwinter and used for many ice fishing escapades. Curiosity about what kinds of stream fish they were catching led to streambank and garage "fish ID" sessions using the very old Fishes of Nebraska pamphlet (1974) and the first edition of Fishes of Missouri (1975). Years later, Bob found himself lead author on The Fishes of Nebraska (2015) and will soon complete the 3rd edition of Fishes of Missouri.

While his staff was arranging affairs and some philanthropists were on their way to New Harmony, Lesueur and his associate, Dr. Gerald Troost, undertook a trip between February 26 and April 20, 1826 that eventually landed them in Missouri, their planned destination to visit the mining country in Madison County (incorporated in 1818). It was a rather arduous journey down the Wabash River to the Ohio and then up the Mississippi River to Commerce Town, which was also named Tawagapati Bottom (which is spelled "Tywappity" today). This is where Lesueur and Troost, on or about March 2, saw the Mississippi River for the first time, and they were quite impressed with the stark and oddly shaped rock bluffs that lined the Missouri bank of the river.

Soon, Lesueur and Troost began their journey to the mining country, particularly, a placed called *Mine la Motte*. On their way, they passed through Jackson, the county seat of Cape Girardeau County, which Lesueur described as "a rather wretched little county seat." From there, the duo had to traverse the "Jackson Road," which linked Jackson to what would become Fredericktown, which now encompasses the early towns of St. Michael and Mine la Motte. The roads to these places were rough and often strewn with obstructions such as downed trees and fallen rocks from cliffs.

Lesueur and Troost spent considerable time in and around Mine la Motte visiting various mines and gathering many fossils, which were carefully drawn by Lesueur on plates that would never appear in print. But it was the encounter with a Mr. Wilkinson that eventually led Lesueur to a stream where he observed and subsequently captured seven specimens of a lamprey that he described in his abbreviated work titled: *American Ichthyology or Natural History of the Fishes of North America: with Coloured Figures from Drawings Executed from Nature* (1827). Lesueur named this species *Petromyzon lamottenii,* named after the "Mine of Lamotte." Lamotte was an anglicized spelling of the name of the French

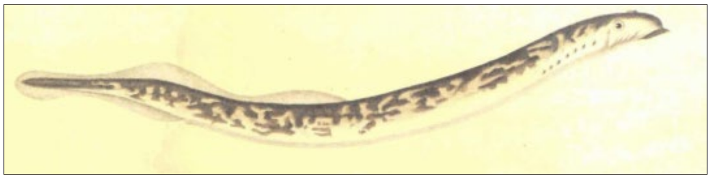


Figure 1. Reproduction of C. A. Lesueur's illustration of *Petromyzon lamottenii* (1827).

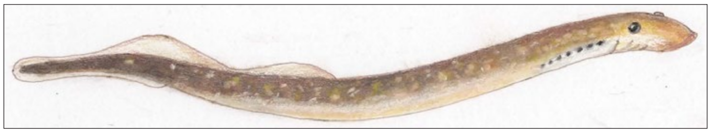


Figure 2. Artist's rendition of *Petromyzon lamottenii* incorporating pigmentation patterns more consistent with modern-day *Lampetra* or *Lethenteron* in Missouri. (Illustration by Sue Corvick)

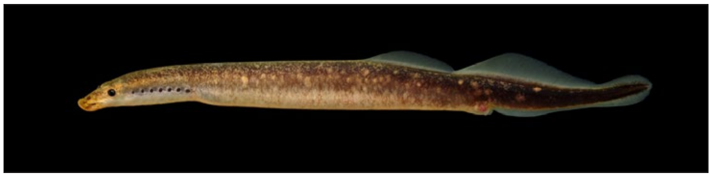


Figure 3. *Lampetra aepyptera:* MISSOURI: Bollinger County: Whitewater River at County Road 930, March 2013. (Photo by Lance Merry)

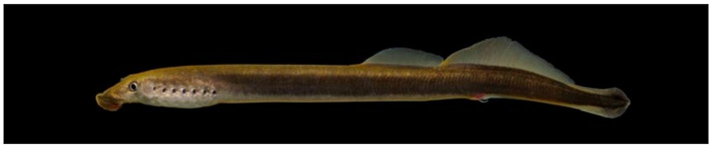


Figure 4. *Lethenteron appendix* (male): MISSOURI: Cape Girardeau County: Whitewater River at Old Plantation Access, March 2013. (Photo by Lance Merry)

Governor of Louisiana, Antoine de la Mothe Cadillac. While lead was discovered here earlier, the mine(s) were developed beginning in 1717 under the authority of Philip Francois Renault, a French politician, businessman, explorer, and metallurgist. Unfortunately, those seven lamprey specimens have been lost, but Lesueur did leave us with fine illustrations of one individual.

This is where the mystery of Lesueur's lampreys deepens. The only clue to the location of the capture site was provided by Lesueur in 1827: *"Of seven individuals which we obtained, but one was a male; the others contained numerous eggs. The water over the rocks on which we observed them, was from 2 inches to 7 feet deep; in a cave by the name of the proprietor, Mr. Wilkinson, it consists of a superposition of sand stones, on scienite* (sic) *and diabase, and will receive a more particular description in an account of an excursion made in April 1826 by Dr. Troost and myself to the Lamotte Mine in Missouri."*

So, which species of lamprey may they have been and where was this "Wilkinson Cave?"

WHICH SPECIES DID LESUEUR CAPTURE?

Because the specimens are lost to time and we are left only with a description and an illustration from 1827 (Figure 1); can we be sure of an identification based on such little information? It seems that Hubbs and Trautman (1937) believed they could. They listed six reasons why Lesueur's lampreys were American Brook Lamprey, *Lethenteron appendix* (at that time given the scientific name of *Entosphenus appendix,* or sometimes referred to as *Lampetra wilder* (Figures 1–4).

1. In 1937, the genus *Lampetra* was known only from the upper Ohio Valley, while *Entosphenus* occurred through the west. Note: this is no longer true as both genera occur in Missouri.
2. The April spawning date better fits *Entosphenus* than *Lampetra*, which would likely spawn in March if it occurred in Missouri. Note: it does occur in Missouri and typically spawns in March but has been observed spawning in mid-April at Missouri's latitude.
3. The teeth as described and drawn by Lesueur do seem to better fit *L. appendix* (Figure 5). Noting, especially, that "the specimen figured by Lesueur's male specimen appears to have lost its corneous teeth before it was pictured. In Lesueur's male specimen the "lateral teeth are bi- or tri-tuberculate"—as Lesueur would hardly have been expected to observe in *Lampetra*."
4. The mottled color, as figured and described by Lesueur; we have now found in the *Entosphenus* as commonly as in the *Lampetra*. However, this does not seem to be the situation in Missouri. Note: *Lampetra aepyptera* (Figure 3) is much more heavily mottled and extensively so compared to *Lethenteron appendix* (Figure 4).
5. Lesueur's statement on habits applies "much better" to the *Entosphenus* than to the little *Lampetra*. Note: this is a bit of a stretch since Lesueur only dedicated two sentences to "habits."
6. Finally, in their only statement that fits both Least and American Brook Lampreys, they note that "*the fins as described fit breeding specimens of Entosphenus as well as those of the Lampetra*."

Apparently, Hubbs and Trautman (1937) were so convinced that Lesueur's lampreys were American Brook Lamprey that they resurrected Lesueur's specific epithet, consequently, *Entosphenus appendix* (De Kay) became *E. lamottenii* (Lesueur) and *Lampetra lamottenii* (Lesueur) became *L. aepyptera* (Abbott). Later tax-

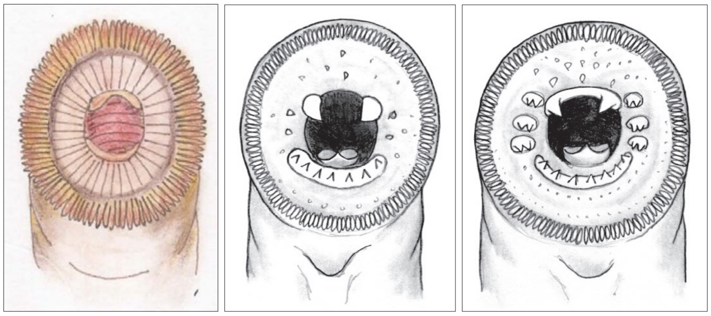


Figure 5. Oral disks of Lesueur's lamprey and Least Brook and American Brook Lampreys. Left: Oral disk of a male lamprey captured by Lesueur at Wilkinson Cave. From Lesueur (1827), redrawn by Sue Corvick. Center: Oral disk of Least Brook Lamprey, illustration by Dave Neely. Right: Oral disk of American Brook Lamprey, illustration by Dave Neely

onomists disagreed with Hubbs and Trautman (1937) as the specific epithet *lamottenii* was suppressed as "unidentifiable" (Rohde 1980); thus, the next available name was elevated: *L. appendix*. The reference to "Bailey and Rohde, *in prep*" (given in several papers) to justify the name change was never published (Fritz Rohde, pers. comm.) yet the name change persisted despite disagreement from Vladykov and Kott (1982).

Despite the volley from Vladykov and Kott (1982), the physical evidence that Lesueur's lampreys were *Entosphenus* (*Lethenteron*) *appendix* is hardly conclusive. Probably the most compelling evidence in favor of *L.* appendix (American Brook Lamprey) is the illustration and description of the teeth. That aside, Vladykov and Kott (1982) believe that Lesueur described the Least Brook Lamprey instead of the American Brook Lamprey. If this is true, then knowing the actual type locality is not a critical issue because the Least Brook Lamprey was described prior to Lesueur's visit to Missouri…if this is true.

WHERE WAS "WILKINSON'S CAVE?"

The Jackson Road provided the main route to several potential river and creek crossings near the Mine la Motte. (Figure 6). Among those crossings are the Castor River, Little Saint Francis River, Saline Creek, Cedar Bottom Creek, and St. Francis River.

Early ichthyologists assumed the lamprey collection site to be in the St. Francis River basin because of its proximity to Mine la Motte (Hubbs and Trautman 1937). Mine la Motte is situated within the Little St. Francis River drainage. However, in the 1980s, William L. Pflieger and his associate Dr. Eugene F. McDonald (a Cape Girardeau optometrist and the discoverer of Spring Cavefish *Forbesichthys agassizii* in Missouri), purportedly obtained a land deed that suggested that "Wilkinson Cave" could have existed on the Castor River. Pflieger had found directions to a possible cave written on one of his maps suggesting it may have been off an old channel of the Castor River south of old State Highway 72 (the old Jackson Road near the defunct town of Castor Station). More recently, Pflieger could not recall if these directions came from McDonald or from a cave database or local cave expert, for example (Pflieger, pers. comm.).

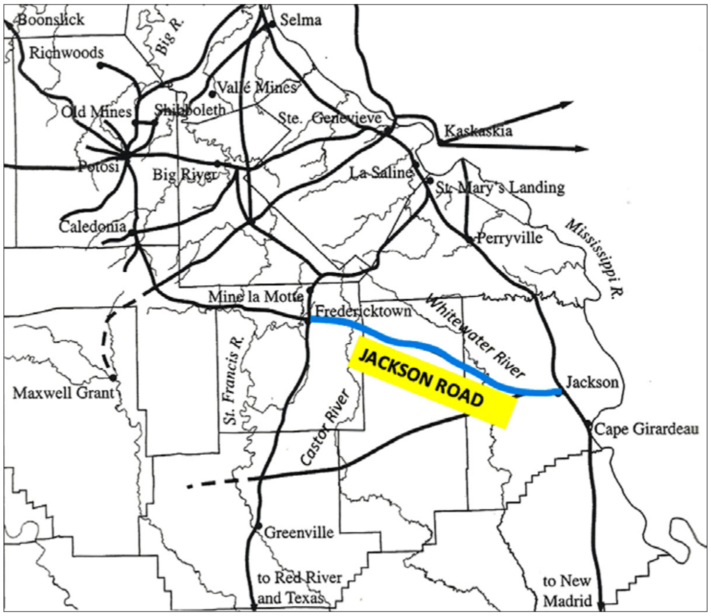


Figure 6. Land Routes in Missouri during the American Period, 1804-1820s; adapted from Schroeder, W. A. Opening the Ozarks: A Historical Geography of Missouri's Ste. Genevieve District, 1760–1830.

I investigated this supposition in April 2021. In notes supplied by Pflieger, an overhanging bank or cave may have existed off a south-approaching gravel road east of the Castor River bridge off Highway 72 at that time (that bridge was constructed in 1923 but was replaced by a new bridge and approach southwest of the old bridge circa 2009). The gravel road no longer exists.

I scoured both banks of the Castor River above and below the old Highway 72 bridge and photo-documented the exercise (made into a PowerPoint presentation available upon request). While a secondary channel does exist as predicted by Pflieger, I recorded no significant overhanging banks or caves in the area. To be certain no such habitat existed, I walked and photo-documented the bluff lines well downstream of the new Highway 72 bridge and, again, no such habitat was discovered.

Given that I was unable to find cave-like habitat and that land deeds I secured did not reveal that Wilkinson owned land near Castor Station, assuredly Lesueur did not observe and capture his lampreys at this location.

There is another reference to a "Wilkinson Cave" reported to me by Mr. Vic Fullmer, who grew up near the Castor River. This cave, also known as "Kelly's Cave," exists "several miles downstream" of Castor Station but sits high above the existing channel of Castor River. Thus, this cave seems far off the beaten path of Jackson Road and Mine la Motte, is situated well above the river, and no land deed under the name "Wilkinson" has surfaced in that area. However, in my research of the name "Wilkinson" there were hits for that name elsewhere in southern Madison County. It is possible that descendants of "Mr. Wilkinson" settled downriver of Castor Station thus deeds that McDonald recovered may have corresponded to Wilkinson's descendants but not to Mr. Wilkinson. Various landowners in that region may have led to the naming of Kelly's Cave as Wilkinson's Cave or vice-versa.

Because the mystery of the location of Wilkinson Cave surrounded Mr. Wilkinson in 1826, the only logical way of proceeding was to find out who was Mr. Wilkinson and since he was the proprietor, where were the lands he owned at the time.

This required a visit to the Missouri State Archives and a search for a "Mr. Wilkinson" and Madison County land deeds that could be secured. Mr. Wilkinson (found to be Mr. Walter (or Watter) Wilkinson) came to Madison County in ~1816 or 1817. His business endeavors were unclear, but he was obviously somehow involved in the mining interests there or perhaps operated accommodations for miners. In any case he was introduced to Lesueur and Troost in 1826 upon their arrival to St. Michael and Mine la Motte.

Wilkinson owned several properties in St. Michael (originally spelled St. Michel): along Saline Creek and one property east of town that may have been in the hill country that borders the Castor River. He also owned 640 acres centered around Cedar Creek (now known as Cedar Bottom Creek and henceforth will be identified as such), southwest of St. Michael. However, I could find no evidence that Wilkinson owned any land along the Castor River either north or south of Jackson Road (this alone ruled out the Castor River where McDonald thought the cave may have

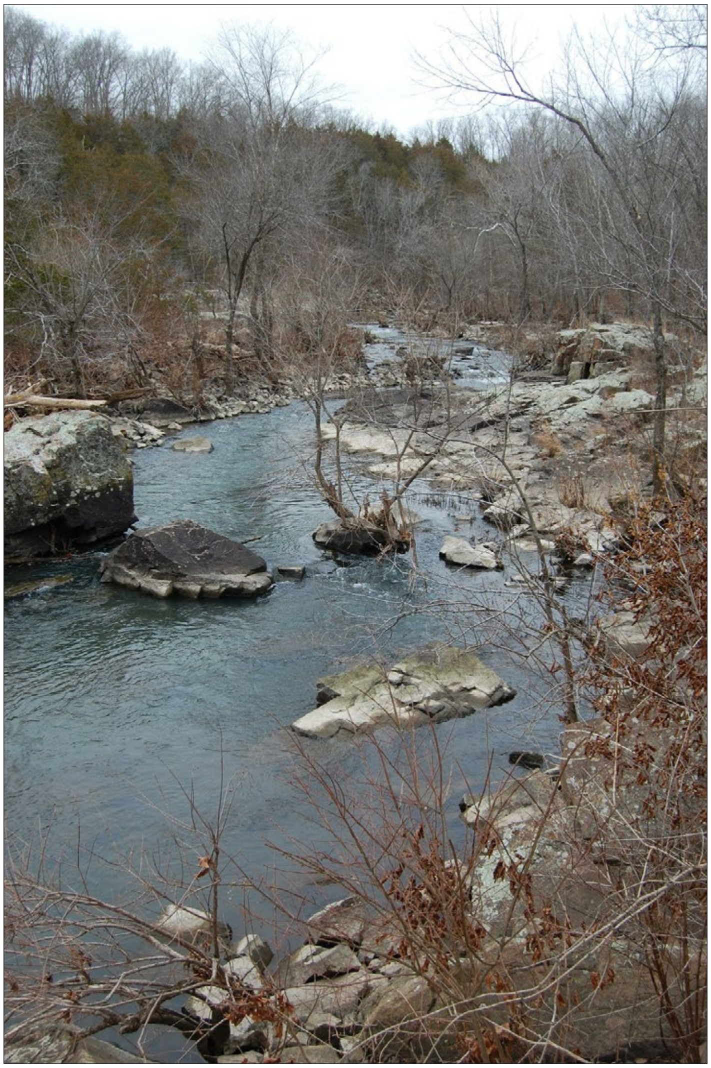


Figure 7. The Little St. Francis River at the edge of Fredericktown, Madison County, Missouri. Not a likely prospect for American Brook Lamprey nor a Lesueur visit since Wilkinson did not own this land.

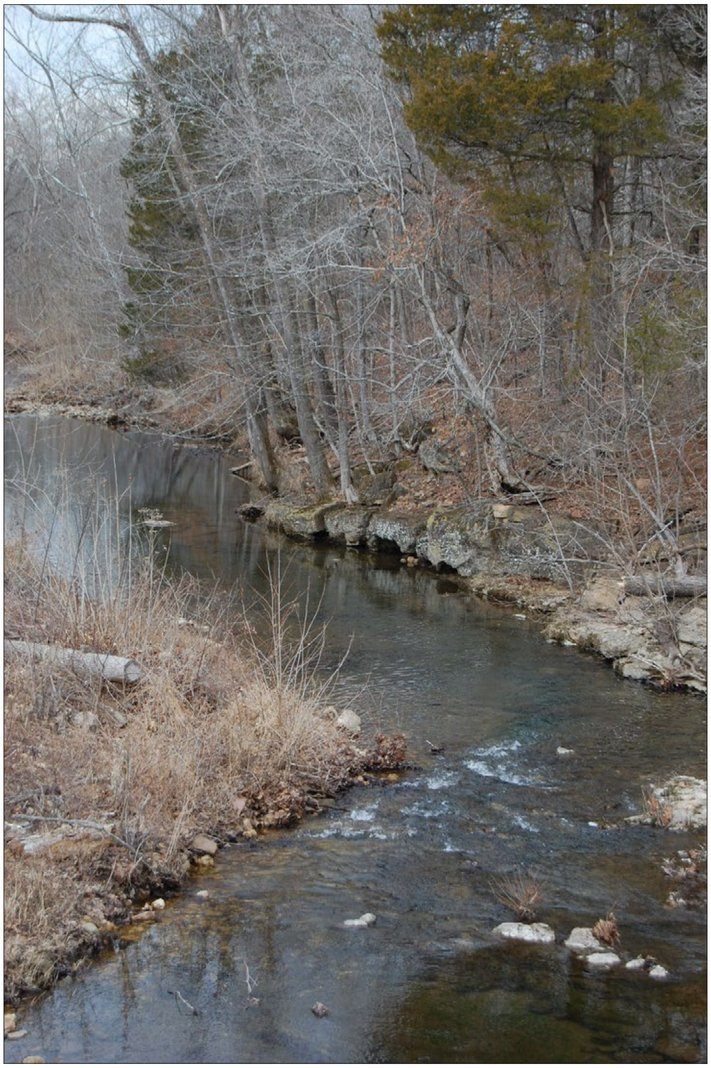


Figure 8. Cedar Bottom Creek, Madison County, Missouri off County Highway E west of Fredericktown. Note the undercut or overhanging bank; cave-like. This spurred my interest to further investigate this creek and Cedar Bottom Farm.

existed). Wilkinson eventually sold his interests and property in Madison County and moved with his wife to Perry County where he lived out his days.

With land deeds in hand, I figured that Wilkinson took Lesueur to one of the following rivers or streams where he captured the lampreys: Saline Creek, probably near its confluence with the Little St. Francis River; the Castor River near present-day Amidon Conservation Area (CA) because Wilkinson owned land toward the hill country that bordered the Castor River in that area; the Little St. Francis River, which flowed near to the Mine la Motte and of which Saline Creek is tributary; and Cedar Bottom Creek, a direct tributary to the St. Francis River.

Thus, I began the reconnaissance process to visit each of these watersheds to determine if any such "cave(s)" existed that match or are reminiscent of Lesueur's description. I eliminated Saline Creek quickly as the stream is quite small and flows through no geology or landforms that Lesueur described. I also quickly ruled out the Castor River near Amidon CA because of the distance and arduous journey through rugged hills to get to the river. In addition, Lesueur's description of the geology at Wilkinson Cave did not match the red granite shut-ins at Amidon. The Little St. Francis River seemed a possibility (some of which is now under a lake). The unimpounded Little St. Francis River is somewhat shut-in-like with jagged rocks and boulders strewn along each bank (Figure 7). However, there seemed to be little evidence of caves or overhanging banks thus it seemed unlikely this is where Lesueur encountered the lampreys and Wilkinson did not own any of the riparian lands along this river.

This left Cedar Bottom Creek as a possible stream where Wilkinson took Lesueur. It was the habitat in this stream that caught my attention (Figure 8). The stream seemed to be a good candidate for Least Brook Lamprey. Cedar Bottom Creek meanders through rugged, hilly, and forested country; thus, much of the stream could not be observed without a canoe or kayak. However, when Cedar Bottom Creek dropped into the St. Francis River bottoms, it was visible again and accessible by county road.

The stream meanders its way along what is known as Cedar Bottom Farm. I attempted to locate a landowner to learn if any such caves may have existed along Cedar Bottom Creek. No one appeared to be at home, but I noticed that the farm had some unusual outbuildings, which seemed to be for a designated purpose. Thinking that this complex may be important enough to find via the Internet, I "Googled it." Much to my surprise, I got a hit and a phone number. When I dialed the number, I got the landowner, Ms. Patricia Rucker, who lives in Delaware!

After explaining who I was and the purpose of the intrusion, I asked about caves in the area and her response floored me "yes, there are caves on my property along the St. Francis River upstream of the confluence with Cedar Bottom Creek." Ms. Rucker went on to explain that while she lived in Fredericktown, she often spent evenings and weekends at the farm where her father raised cattle. As a little girl, she used to climb the bluffs along Cedar Bottom Creek and the St. Francis River and play near the caves (she wouldn't go in the caves, too spooky, she said). These caves are situated high above the St. Francis River on her property thus seemed very unlikely that the river would have ever flowed into the caves during Lesueur's time. Today, the federally-endangered Gray Bat *Myotis grisescens* was detected near these caves (but they do not use caves) as told to Ms. Rucker by the Madison County Highway Department, who was forced to move the Highway E bridge over the St. Francis River to the south of the proposed route (to its present location).

At this point I was quite intrigued with the area and I asked Ms. Rucker if she was aware of caves along Cedar Bottom Creek elsewhere in the county or along the St. Francis River. She was unaware of any caves along Cedar Bottom Creek but suggested I talk to neighbor Mr. Jeff Royer, who owned frontage along the St. Francis River that included the same bluff line that encompasses the caves and the confluence of Cedar Bottom Creek to the St. Francis River.

I asked how many acres on the farm and she replied 640 acres. She went on to say that when her father purchased the farm in 1949, it had 640 acres and they bought an additional 40 acres along the St. Francis River so they could have access to the stream. Much later, the family purchased 10 acres at the confluence of Cedar Bottom Creek and the St. Francis River. These 10 acres may be quite important with respect to the land that Walter Wilkinson once owned as described below. In 2017, the family sold 20 acres in the northwest corner of the farm (part of the 40 acres purchased in 1949), to Mr. Royer, which included St. Francis River frontage (this is also quite important with respect to caves on the St. Francis River as described below). Interestingly, Ms. Rucker has abstracts of her property that date to 1833 and the farm had been 640 acres as detailed in her abstracts during the entire time. At this point I was convinced that these 640 acres was the same property that Wilkinson owned as described in the land deed of 1823.

However, further investigation into Ms. Rucker's abstracts did not reveal the name "Walter Wilkinson." Although the Rucker abstracts begin in 1833, details make it clear that a fellow by name of John St. Claire owned the land when the area belonged to France and he continued to own the land after the Louisiana Purchase beginning in 1803. The United States confirmed that St. Claire owned the land in July 1836 through *An Act Confirming Claims to Land in the State of Missouri and for other Purposes.*

It became clear that Wilkinson did not own these 640 acres now owned by Ms. Rucker. So, where was this Wilkinson property? The land deed of 1823 did not clearly define the boundaries of the 640 acres "centered on Cedar Bottom Creek." The key phrase is "centered on Cedar Bottom Creek" suggesting that the Wilkinson land extended both north and south of the creek. Recall from above that Ms. Rucker's father purchased an additional 40 acres of St. Francis River frontage in 1949 and sometime later 10 acres that included Cedar Bottom Creek at the confluence of the creek and the St. Francis River. I am under the impression that these 50 acres were part of the Wilkinson property that is now owned by Jeff Royer to the north of Cedar Bottom Farm (the 20 acres sold to Mr. Royer in 2017) and at the confluence of the creek and the St. Francis River. Thus, it seems likely that Wilkinson owned frontage land to the St. Francis River both above and below the existing County Highway E bridge, which today would bisect the Wilkinson property. When Ms. Rucker's father purchased Cedar Bottom Farm in 1949, there was no County Highway E and no bridge crossing the St. Francis River. Instead, the properties in that area were connected by Madison County Road 508, which provided a transportation route to Fredericktown, which seems like a convenient transportation route that could have been taken by Lesueur and Wilkinson. This county road that followed the St. Francis River no longer exists south of County Highway E (Patricia Rucker, pers. comm.).

The next landowner to contact was Mr. Jeff Royer. Royer now owned the 20 acres in the northwest corner of the 40 acres that Ms. Rucker's father purchased in 1949. Thus, Cedar Bottom Farm

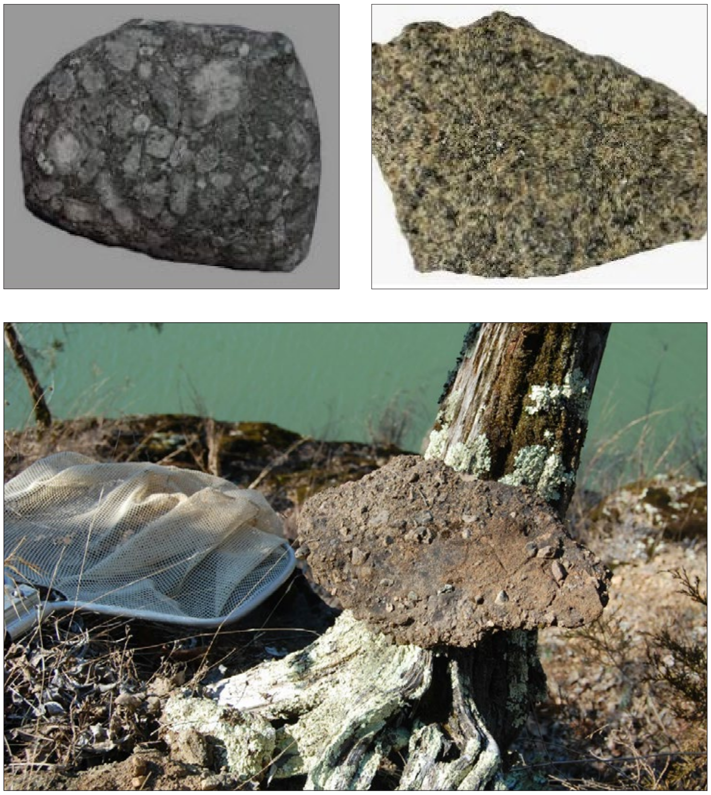


Figure 9. Geology of Wilkinson Cave as described by Lesueur contained syenite (top left) and diabase (dolerite; top right). Photo at bottom shows sandstone superpositioned over syenite at the site.

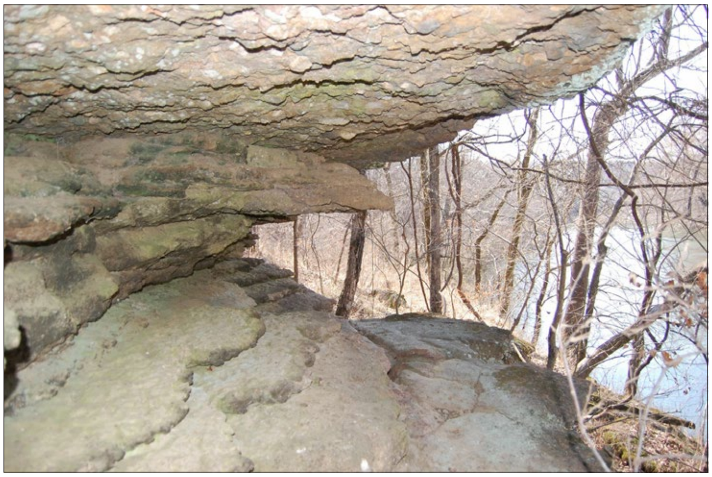


Figure 10. This view from inside a cave shows some of the geology and the St. Francis River in the background. It appears that embedded sandstone is superpositioned over syenite on the ceiling of the shelf. The "caves" are not so much cavernous as people think when they hear the word "cave" but instead are overhanging shelves carved out by past millennia of water flowing by them.

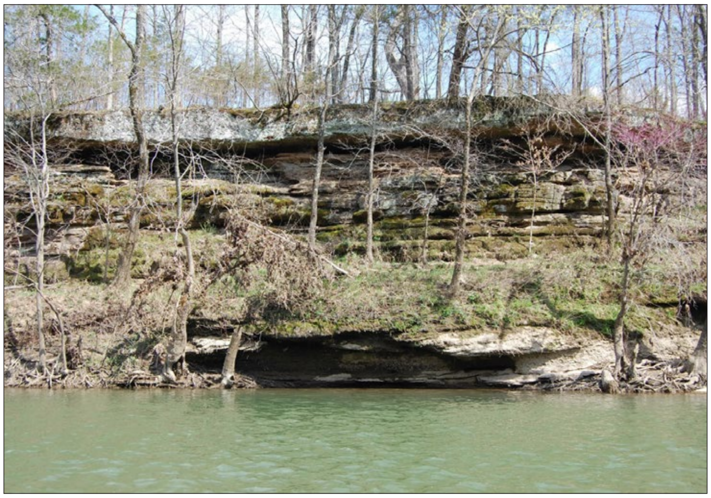


Figure 11. I believe this to be the actual site where Wilkinson took Lesueur where he observed the lampreys and captured seven specimens in 1826. Lesueur wrote: *"The water over the rocks on which we observed them, was from 2 inches to 7 feet deep; in a cave by the name of the proprietor, Mr. Wilkinson, it consists of a superposition of sand stones, on scienite* (sic) *and diabase."* At the river stage in which I took this photograph (very near to median flow) the water in the cave was about 2 inches deep and off the edge of the ledge into the St. Francis River I had a 5-foot-long canoe paddle that when I submerged it into the river, it did not strike bottom.

currently includes the 10 acres at the Cedar Bottom Creek confluence and approximately 2/3 of the St. Francis River frontage that partially composed the 40 acres that is owned by Royer. The remaining 1/3 of the river frontage (the most upstream segment) owned by Royer is where more caves exist, including the only cave situated such that the St. Francis River could enter the opening. Therefore, all the caves in this reach of the St. Francis River were part of Cedar Bottom Farm until 2017.

When I asked Mr. Royer about caves along the St. Francis River bluff line (east bank of the river), he informed me that there are caves on his property, which he had visited several times and fished directly under them!

At this time, I was given permission to examine the caves along the St. Francis River by Ms. Rucker and Mr. Royer. Thus, I arranged for two reconnaissance missions to examine the geology and layout of the St. Francis River caves to determine if it matched Lesueur's descriptions.

Lesueur stated that the geology of the formations and caves within were a "superposition of sandstones on scienite (sic) and diabase." Syenite is coarse-grained gray igneous rock composed mainly of feldspar and ferromagnesian minerals. Diabase, also called dolerite, is fine- to medium-grained, dark gray to black igneous rock (Figures 9 and 10).

Examination of the bluff formation and caves revealed sandstones and igneous conglomerates consistent with Lesueur's description. While floating the St. Francis River to obtain a wider view of the bluff, a cave-like shelf became apparent that upon closer examination fit Lesueur's description almost perfectly and provided the best evidence possible that this was the cave where Lesueur observed and collected his lampreys (Figure 11, with further elaboration that identifies this cave as the collection site).

DO LAMPREYS EXIST AT THIS LOCATION IN THE ST. FRANCIS RIVER?

On 14 April 2021, Jacob Westhoff, Mark Chowning, Colton Hampton, and I proceeded to sample the presumptive Wilkinson Cave and the immediate area to detect lampreys. We used a backpack electrofishing unit, dip-nets, and various seines (Figure 12). We sampled the cave and as much of the bluff as we could before the water became too deep to work. We also extensively sampled a large riffle and run upstream of the site, including undercut, root-filled banks and silty flats that could have held ammocoetes. Overall, we surveyed approximately 1,890 linear feet (more if one were to include each side of the river's banks).

We captured 32 species of fishes (including the state endangered St. Francis River Longnose Darter, *Percina* sp. *cf. nasuta*, Figure 13), which were composed of minnows, suckers, catfishes (madtoms) sunfishes, and eight species of darters, but we captured no lampreys!

Of course, a single sample in the middle of April to search for lampreys means virtually nothing if one does not capture the species in question. But there is a little bit more to this observation: 1) other than Lesueur's capture of what some ichthyologists once believed were American Brook Lampreys, there are no other captures of this species from the St. Francis River or its tributaries. Ironically, American Brook Lampreys have been captured from adjoining watersheds: Black River to the west and Castor River the east, and 2) interestingly, Least Brook Lamprey have been collected from the mainstem St. Francis River, all of them (three records) below Madison County (in Wayne County) and all are old records (prior to 1990).

Prospectus: considerable time had been devoted to simply finding Wilkinson Cave and forging good relationships with respective landowners to conduct several reconnaissance missions to verify the location. Time simply got away from the

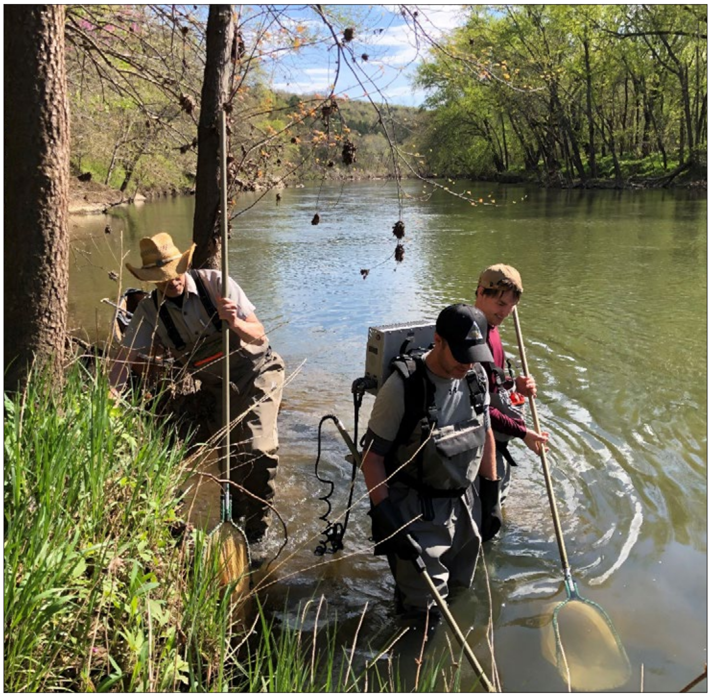


Figure 12. Electrofishing at base of bluff just downstream of Wilkinson Cave. Westhoff is operating the shocker. Dippers are Hrabik (left) and Chowning. (Photo by C. Hampton)

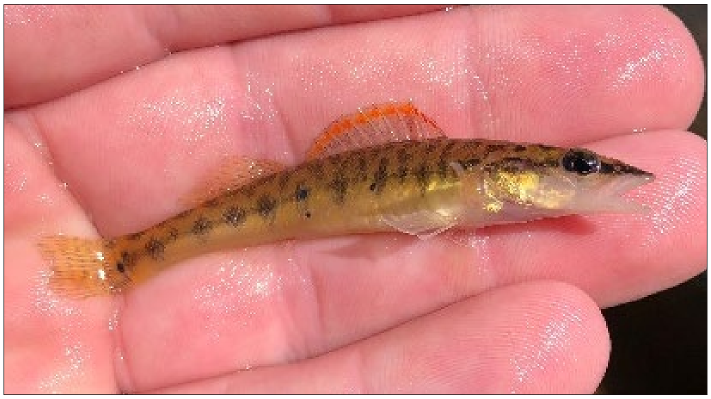


Figure 13. Male *Percina* sp. *cf. nasuta* captured from near downstream tip of gravel bar (becomes an island at high river stages). Photo by C. Hampton.

author to adequately survey Cedar Bottom Creek and the St. Francis River for lampreys. To conclude this investigation, the author will begin surveying Cedar Bottom Creek and the St. Francis River in February 2022 to determine which, if any, lampreys frequent this reach of the St. Francis River watershed. Possibly, then, the mystery of Lesueur's lampreys at Wilkinson Cave will be solved.

APPENDIX: LIST OF FISH SPECIES DESCRIBED BY LESUEUR AND PRESENT IN MISSOURI.

Mooneye	*Hiodon tergisus* (1818)
American Eel	*Anguilla rostrata* (1817)
Gizzard Shad	*Dorosoma cepedianum* (1818)
Quillback	*Carpiodes cyprinus* (1817)
Blue Sucker	*Cycleptus elongatus* (1817)
Northern Hog Sucker	*Hypentelium nigricans* (1817)
Black Redhorse	*Moxostoma duquesnei* (1817)
Shorthead Redhorse	*Moxostoma macrolepidotum* (1817)
Yellow Bullhead	*Ameiurus natalis* (1819)
Brown Bullhead	*Ameiurus nebulosus* (1819)
Blue Catfish	*Ictalurus furcatus* (1840)
Grass Pickerel	*Esox americanus vermiculatus* (1846)
Chain Pickerel	*Esox niger* (1818)
Banded Killifish	*Fundulus diaphanus* (1817)
Black Crappie	*Pomoxis nigromaculatus* (1829)

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AHEAD BY A WHISKER: FRESHWATER CATFISH (FAMILY ICTALURIDAE) DIVERSITY IN NORTH CAROLINA

Bryn H. Tracy, Scott A. Smith, Jesse L. Bissette, and Fred C. Rohde

As a follow-up to Mike Pinder's article on Virginia's six species of diminutive catfishes, known as madtoms (Pinder 2021), North Carolinians also like to boast of their six madtom species, plus three madtom forms awaiting formal descriptions. Additionally, the pain inflicted by a Virginian Tadpole Madtom *Noturus gyrinus* pales in comparison to that of our Carolina Madtom *Noturus furiosus*. In fact, Jordan (1889) described Carolina Madtom as follows: "*This species is the most strongly armed of the North American Catfishes, and according to Professor* [Oliver P.] *Jenkins the poison of its axillary gland is more virulent than that of other species*". So, take that you ol' Dominion!

There are 18 species of catfishes in North Carolina including three scientifically undescribed species (Table 1) (Tracy et al. 2020). You might have heard people calling them Bullheads, Mud Cats, Butter Balls, Blue Channel Cats, Madtoms, Squealers (for the pain inflicted), or other more colorful colloquial names. But each species has its own scientific (Latin) name, which coincidentally actually means something (Table 2), and an American Fisheries Society-accepted common name. Catfishes are found throughout North Carolina in streams, swamps, big rivers, and reservoirs from Cherokee County in the mountains to Dare County along the Albemarle Sound. Distributional maps for every species may be found in Tracy et al. (2020).

Sometime between 1585–1593, John White illustrated in remarkable and accurate detail what we believe to be White Catfish *Ameiurus catus* labeled with the Algonquin word used by the Croatoan First Peoples, *Keetrauk* (https://www.coastalcarolinaindians.com/updated-algonquian-word-list-by-scott-dawson/) for catfish, and noted: *"Some 2. foote and a half in length."* (Figure 1). This measurement is almost identical to that (24.4 inches) reported almost 425 years later by Rohde et al. (2009).

More than a century after John White painted this fish, catfish was mentioned as occurring in North Carolina's waters by John Lawson in 1709: "*Cat-fish are a round blackish Fish, with a great flat head, a wide mouth, and no Scales; they something resemble Eels in Taste. Both this sort, and another that frequents the Salt Water* [perhaps Hardhead Catfish *Ariopsis felis* or Gaftopsail Catfish *Bagre marinus*], *are very plentiful* (Lawson 1709, 160).

Catfishes range in size from the diminutive "Broadtail" Madtoms of just a few inches in length to the behemoth Blue Catfish with maximum lengths approaching 5 feet. Similarly, they may weigh just a few ounces for the smaller madtoms and up to 150 pounds for Blue Catfish. Many species are recreationally and commercially important as delectable table fare such as Blue Catfish, Channel Catfish, and Flathead Catfish. Game species include Blue Catfish, Channel Catfish, Flathead Catfish, and bullheads, *Ameiurus* spp., whereas the smaller madtom species, *Noturus* spp., are considered non-game species. Several species have been introduced, legally or illegally, outside their historical ranges. For example, the Margined Madtom has been collected and transported outside its native range east of the Appalachian Mountains, and used as bait for catching Smallmouth Bass *Micropterus dolomieu* in the New River and Watauga River basins; similar illegal introductions of Margined Madtom have also been documented in Virginia (Jenkins and Burkhead 1994, Pinder 2021).

In North Carolina, three species of madtom are found in only one basin and one physiographic region (Figure 2, 3; Table 3): 1) Mountain Madtom in the lower French Broad (Mountains); 2) the "Cape Fear Broadtail" Madtom in the Cape Fear (Coastal Plain); and 3) the "Lake Waccamaw Broadtail" Madtom in the Waccamaw basin (Coastal Plain). Brown Bullhead is our most widely distributed species. It is found in 18 of our 21 basins, but there are no records of its occurrence in the Nolichucky, Savannah, or Shallotte basins (Tracy et al. 2020).

Our least speciose basin is the small, headwaters basin, the Savannah, where only Margined Madtom and Snail Bullhead are found. However, more species of catfishes, 12, are found in the Roanoke River basin than in any of the other 21 basins. Those 12 species include 5 species that have been introduced from other basins within or from drainages outside of North Carolina: Snail Bullhead,

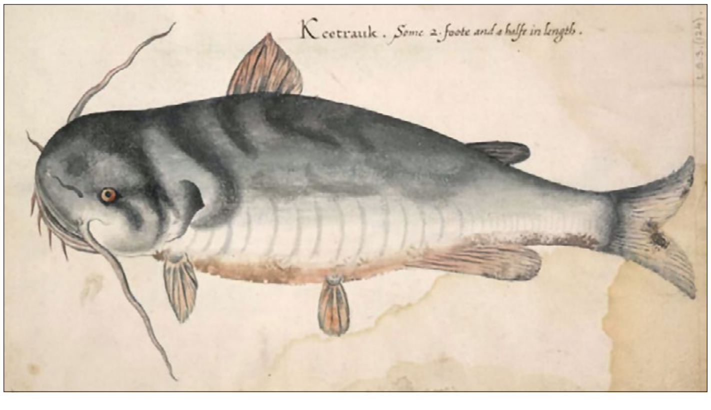
Keetrauk . Some 2. foote and a halfe in length .

Figure 1. Painting of White Catfish by John White, 1585–1593. Painting courtesy of the British Museum, Museum No. SL,5270.107 (https://www.britishmuseum.org/collection/object/P_SL-5270–107).

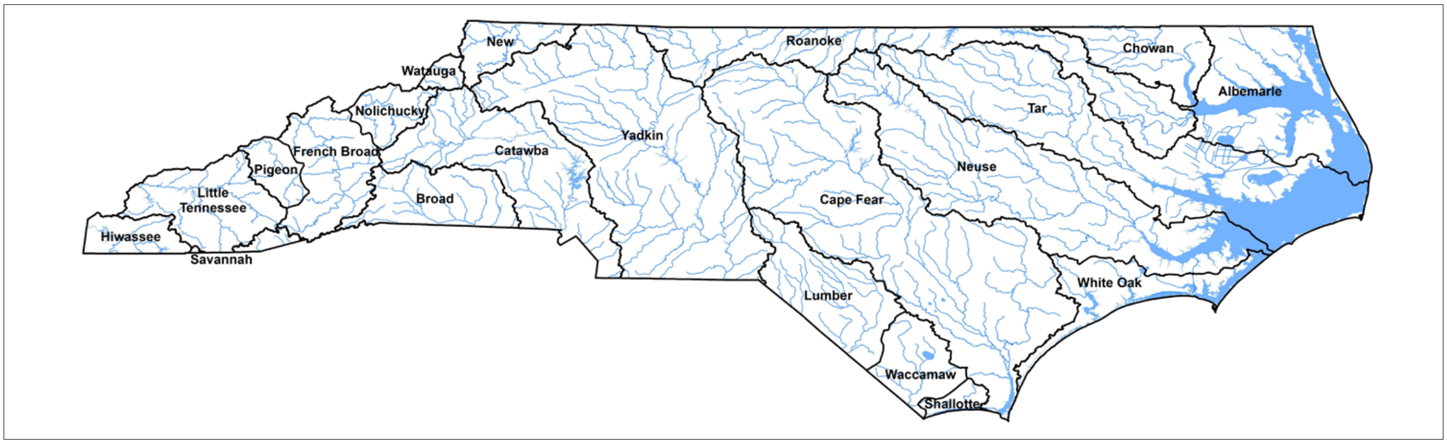

Figure 2. North Carolina's 21 river basins. Map originally appeared in Tracy et al. (2020).

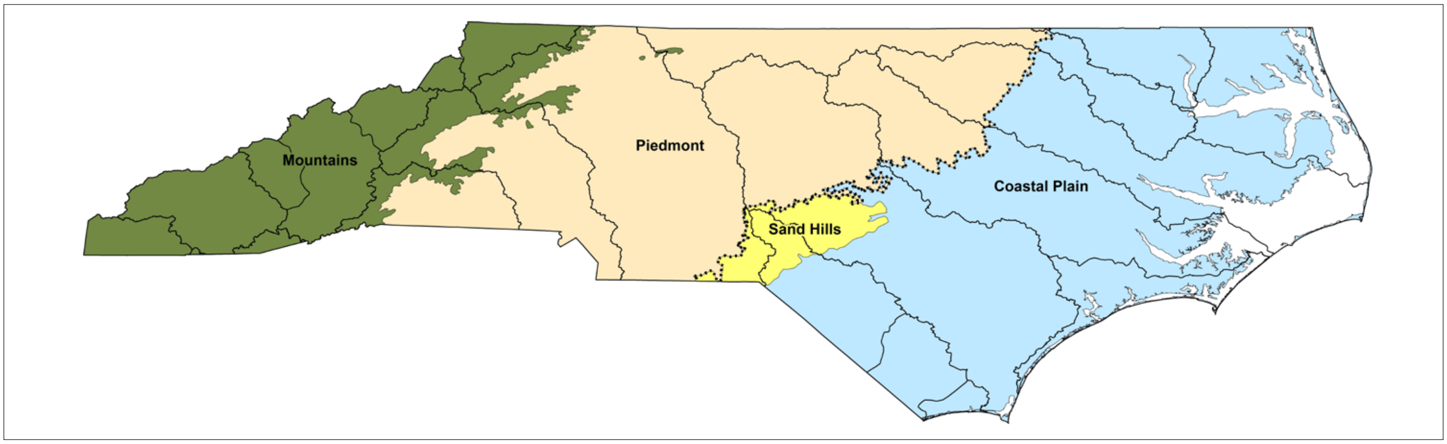

Figure 3. North Carolina's four physiographic regions. Dashed black line denotes the approximate location of the Fall Zone.

Black Bullhead, Flathead Catfish, Blue Catfish, and Channel Catfish. The seven native species in the Roanoke basin include the Margined, Orangefin, and Tadpole madtoms; White Catfish, Brown Bullhead, Flat Bullhead, and Yellow Bullhead. Seven species are considered imperiled in North Carolina: 1) State Endangered – Stonecat and Orangefin Madtom; 2) State Threatened – Carolina Madtom; and 3) State Special Concern - all three "undescribed "Broadtail" Madtom species (NCAC 2017; NCNHP 2020; NCWRC 2017).

Key characteristics for properly identifying North Carolinian catfishes include the shape of the caudal and anal fins, the color of the barbels surrounding the mouth, and body and fin coloration (please refer to the accompanying Identification Key to the Species of Catfishes (Family Ictaluridae) in North Carolina). Most species can easily be told apart from one another, with the possible exceptions of Flat Bullhead vs. Snail Bullhead and Black Bullhead vs. Brown Bullhead.

If you have troubles with your identifications, just send us (https://ncfishes.com/contact/) an e-mail and include as many quality digital photographs as you can along with all the pertinent locality descriptors so that we will know from where the fish came.

Table 1. Species of catfishes found in North Carolina. Common names enclosed within quotation marks ("") are scientifically undescribed species.

Scientific Name	American Fisheries Society Accepted Common Name	Scientific Name	American Fisheries Society Accepted Common Name
Ameiurus brunneus	Snail Bullhead	*Noturus flavus*	Stonecat
Ameiurus catus	White Catfish	*Noturus furiosus*	Carolina Madtom
Ameiurus melas	Black Bullhead	*Noturus gilberti*	Orangefin Madtom
Ameiurus natalis	Yellow Bullhead	*Noturus gyrinus*	Tadpole Madtom
Ameiurus nebulosus	Brown Bullhead	*Noturus insignis*	Margined Madtom
Ameiurus platycephalus	Flat Bullhead	*Noturus* sp. "Cape Fear Broadtail" Madtom	
Ictalurus furcatus	Blue Catfish	*Noturus* sp. "Lake Waccamaw Broadtail" Madtom	
Ictalurus punctatus	Channel Catfish	*Noturus* sp. "Pee Dee Broadtail" Madtom	
Noturus eleutherus	Mountain Madtom	*Pylodictis olivaris*Flathead Catfish	

Table 2. The meanings of the scientific names of catfishes (Family Ictaluridae) found in North Carolina. Adopted from the ETY-Fish Project by Christopher Scharpf and Kenneth J. Lazara, accessed September 30, 2020, http://www.etyfish.org/.

Ameiurus **Rafinesque 1820:** *a-*, without; *meiosis*, to reduce; *urus*, tailed, literally "not curtailed," referring to absence of deep notch in caudal fin compared to forked tail of *Ictalurus*

- ***A. brunneus*** **Jordan 1877:** brown, referring to brownish color of young and juveniles
- ***A. catus*** **(Linnaeus 1758):** Latin for cat, referring to its cat-like whiskers
- ***A. melas*** **(Rafinesque 1820):** black, referring to color (which varies to yellowish and brown)
- ***A. natalis*** **(Lesueur 1819):** Latin for "of or belonging to birth," often applied to Christmas (*Noel* in French), as reflected in Lesueur's vernacular name for this catfish, "Pimelode Noël," allusion not explained but almost certainly in honor of Simon Barthélemy Joseph Noël de la Morinière (1765–1822), French naturalist, journalist, author, and fisheries inspector who devoted 20 years to a projected six-volume history of fisheries of which only one volume (1815) appeared (Lesueur mentioned Noël in his 1817 description of the American Eel, *Anguilla rostrata*); most sources claim name means "having large nates or buttocks," referring to either a swollen and elevated caudal peduncle, a large adipose fin, or the swollen head and nape muscles of breeding males, an etymological error apparently based on the assumption that *natalis* was the adjectival form of the Latin noun *natis* (rump or buttocks) (https://etyfish.org/name-of-the-week2019/, August 7, 2019; Scharpf 2020a).
- ***A. nebulosus*** **(Lesueur 1819):** cloudy, referring to cloudy (i.e., mottled) yellow-brown color
- ***A. platycephalus*** **(Girard 1859):** *platys*, flat; *cephalus*, head, referring to "very much depressed" head

Ictalurus **Rafinesque 1820:** *ichthys*, fish; *aelurus*, cat, i.e., "cat-fish"

- ***I. furcatus*** **(Lesueur 1840):** forked, referring to forked tail
- ***I. punctatus*** **(Rafinesque 1818):** spotted, referring to small, dark spots on body

Noturus **Rafinesque 1818:** *noton*, back; *oura*, tail, i.e., tail over the back, referring to connected caudal and adipose fins

- ***N. eleutherus*** **Jordan 1877:** free, referring to "free adipose fin," i.e., incomplete fusion of adipose and caudal fins
- ***N. flavus*** **Rafinesque 1818:** yellow, referring to the Kentucky (USA) specimens Rafinesque examined, "entirely of rufous yellow"
- ***N. furiosus*** **Jordan & Meek 1889:** mad, "the poison of its axillary gland is more virulent than that of" its congeners
- ***N. gilberti*** **Jordan & Evermann 1889:** in honor of friend and colleague Charles H. Gilbert (1859–1928), ichthyologist and fisheries biologist
- ***N. gyrinus*** **(Mitchill 1817): L**atinization of *gyrinos*, tadpole, referring to tadpole-like shape
- ***N. insignis*** **(Richardson 1836):** remarkable or extraordinary, allusion not evident since Richardson did not provide a description; Taylor, in his 1969 revision of the genus, said the "probable intention [of the name] was to emphasize the [yellowish] color and the long adipose fin, features which were at one time considered unique"

Pylodictis **Rafinesque 1819:** *pelos*, mud; *ichthys*, fish, with the "*d*" likely inserted for euphony, reflecting several local vernaculars (e.g., mudcat, mudfish, mudsucker); Rafinesque wrote that the fish "lives on muddy bottoms, and buries itself in the mud in the winter"

- ***P. olivaris*** **(Rafinesque 1818):** olive, referring to its coloration

GLOSSARY

(Adapted from Jenkins and Burkhead 1994)

Adipose Fin: A small or medium-sized, fleshy fin lacking rays and spines and occurring on the dorsum between the dorsal and caudal fins

Emarginate: A fin margin with a slight middistal concavity

Maxillary Barbel: Dorsolateral barbel located at the "corner" of the mouth

Premaxillary band of teeth (tooth patch): Tooth patch located at the anterior portion on the "roof" of the mouth; best observed by placing the fish on its back and prying open it mouth

Nape: The dorsal area between the posterior end of the head (occiput) and the dorsal fin

Occiput: The posterodorsal portion of the head, immediately anterior to the nape

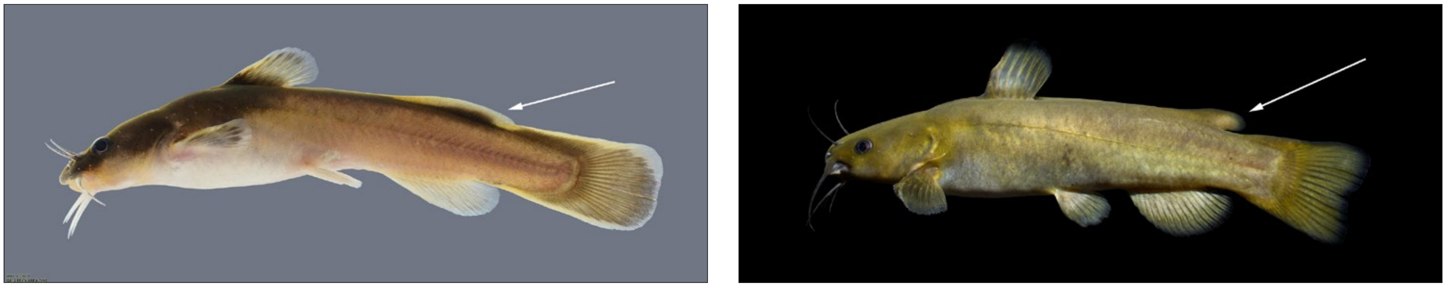

Figure 1. Left: Adipose fin attached to caudal fin. Right: Adipose fin free from caudal fin. (Left photograph courtesy of NANFA)

IDENTIFICATION KEY TO THE SPECIES OF CATFISHES (FAMILY ICTALURIDAE) IN NORTH CAROLINA[1,2]

(Please refer to NCFishes.com for additional pictures and characteristics for all species)

1a. Adipose fin attached to caudal fin (Figure 1). Maximum total length less than 200 mm, except for Stonecat, *Noturus flavus* 2

1b. Adipose fin free from caudal fin (Figure 1). Maximum total length far exceeding 200 mm 9

2a. Band of teeth in upper jaw with backward lateral extensions (Figure 2). Light blotch on nape (Figure 3). Restricted to Nolichucky, lower French Broad, and Little Tennessee River basins . . . . **Stonecat, *Noturus flavus***

2b. Band of teeth in upper jaw without backward lateral extensions. No light blotch on nape. Range not restricted to Nolichucky, lower French Broad, and Little Tennessee River basins 3

3a. Body with dorsal blotches (Figure 4) 4

3b. Body without dorsal blotches (Figure 4) 5

4a. Range restricted to Tar and Neuse River basins (Figure 5) . . . . **Carolina Madtom, *Noturus furiosus***

4b. Range restricted to lower French Broad River basin (Figure 5). . . . . **Mountain Madtom, *Noturus eleutherus***

5a. Range restricted almost entirely to the Sand Hills and Coastal Plain 6

5b. Range not restricted to the Sand Hills and Coastal Plain 8

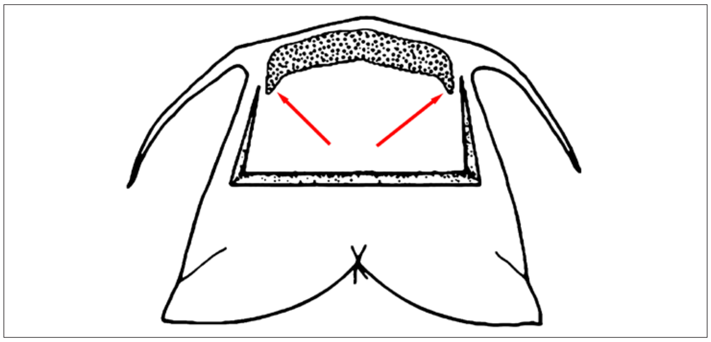

Figure 2. Red arrows pointing to the premaxillary band of teeth in the upper jaw with backward lateral extensions in Stonecat and Flathead Catfish.

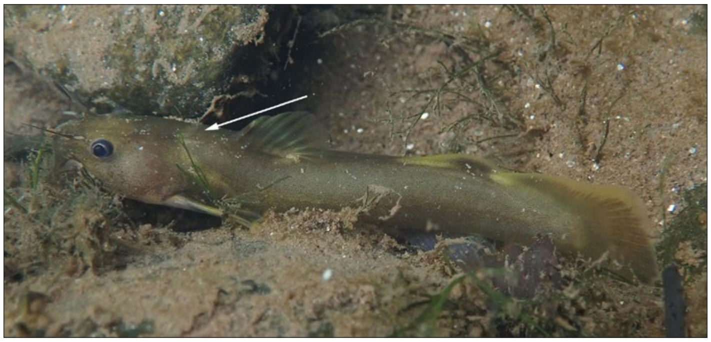

Figure 3. Stonecat showing light blotch on nape. (Photograph courtesy of Luke Etchison, North Carolina Wildlife Resources Commission)

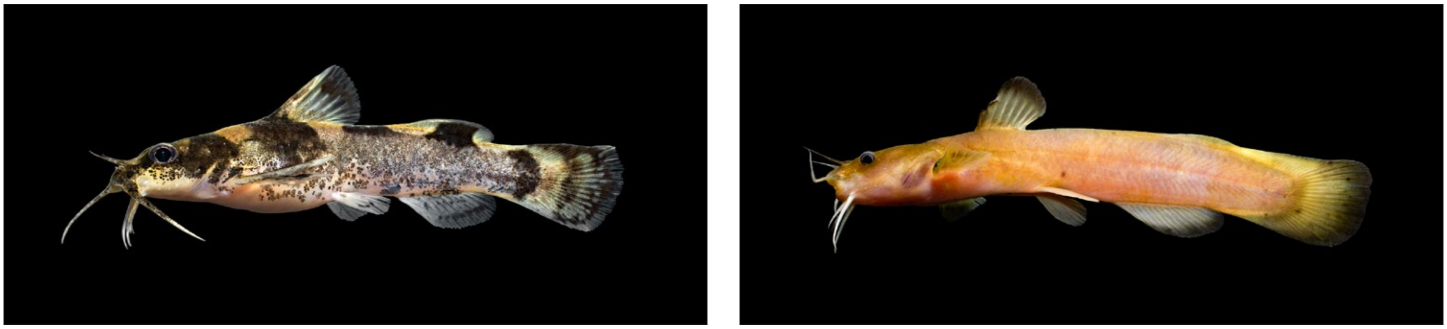

Figure 4. Left: Body with dorsal blotches. Right: Body without dorsal blotches.

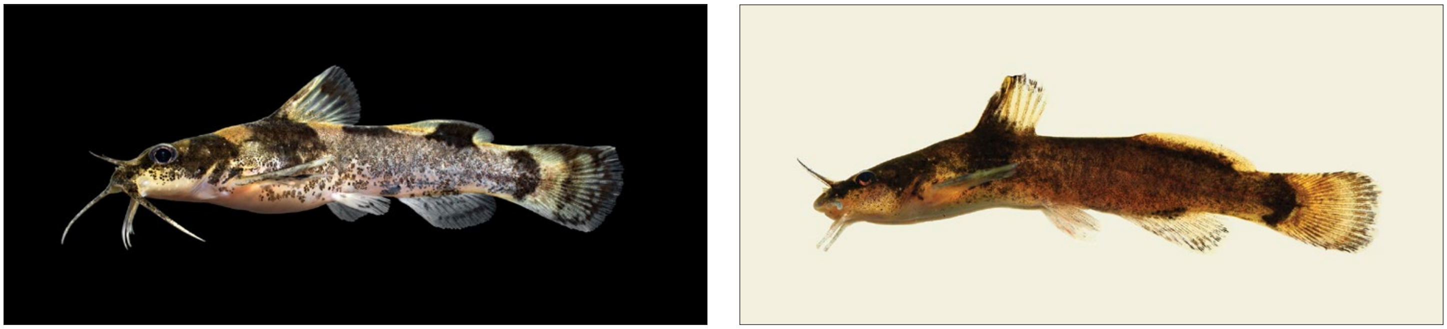

Figure 5. Left – Carolina Madtom; Right – Mountain Madtom.

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[1] Permission to use illustration (Figure 47, page 529 in Jenkins and Burkhead (1994)) was granted by the American Fisheries Society, October 11, 2020.

[2] All photographs taken by Jesse Bissette, Scott Smith, and Fritz Rohde.

6a. Mouth terminal or very slightly subterminal (Figure 6); jaws of equal length. Prominent, narrow, and dark mid-lateral streak present. Caudal fin large. Nasal barbel when pulled backwards extends as far behind eye as occurs in front of eye.. . . . . **Tadpole Madtom, *Noturus gyrinus***

6b. Mouth subterminal (Figure 6); upper jaw projects forward of lower jaw. Caudal fin small with a dark blotch at its base. Nasal barbel extends only to posterior edge of eye or slightly beyond. Thin dark mid-lateral streak usually absent or indistinct 7

7a. Modally 14 anal rays and 55 caudal fin rays. Caudal fin length : height ratio of 1.11. Broad head. Found only in Lake Waccamaw (Figure 6, Right) . . . . ***Noturus* sp. "Lake Waccamaw Broadtail" Madtom**

7b. Modally 16 anal rays and 59–60 caudal fin rays. Caudal fin length : height ratio of 1.34. Found only in Lumber and Waccamaw River basins (Figure 7). . . . .***Noturus* sp. "Pee Dee Broadtail" Madtom**

7c. Modally 16 anal rays and 60 caudal fin rays. Caudal fin length : height ratio of 1.42. Found only in lower Cape Fear River basin (Figure 7) . . . . ***Noturus* sp. "Cape Fear Broadtail" Madtom**

8a. Caudal fin margin pale, the pale portion slightly to distinctly wider on upper lobe (often forming somewhat a triangular pale area, but not readily apparent in photograph) than on lower lobe (Figure 8). Anal rays 14–16. Caudal fin submarginally is distinctly darker on lower lobe than upper lobe. Chin behind barbels strongly papillose. Range restricted to the upper Dan River watershed in the Roanoke basin . .**Orangefin Madtom, *Noturus gilberti***

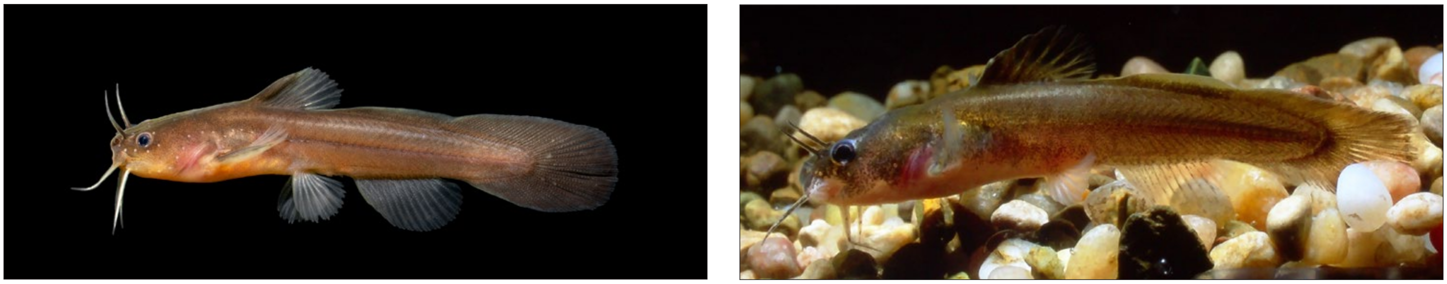

Figure 6. Left: Tadpole Madtom with terminal mouth and mid-lateral streak. Right: Subterminal mouth and mid-lateral streak absent (*Noturus* sp. "Lake Waccamaw Broadtail" Madtom).

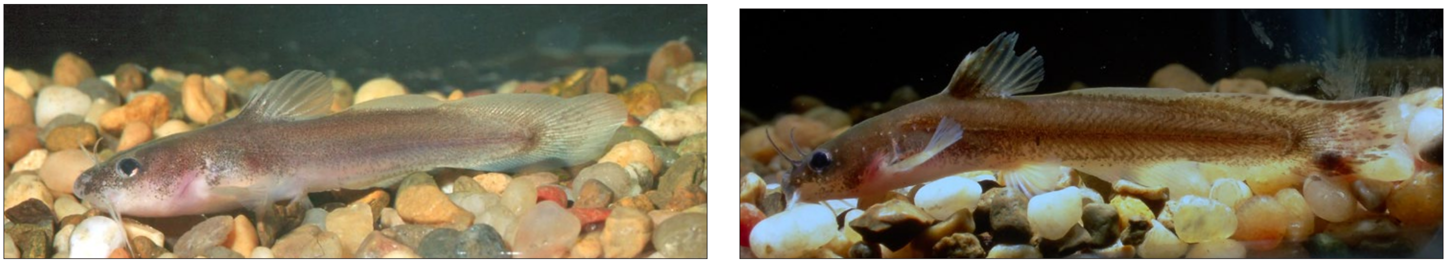

Figure 7. Left: *Noturus* sp. "Pee Dee Broadtail" Madtom. Right: *Noturus* sp. "Cape Fear Broadtail" Madtom.

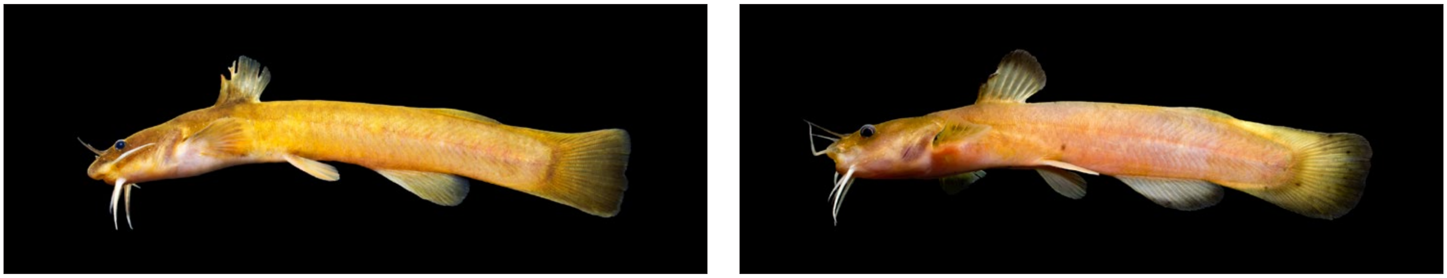

Figure 8. Left: Orangefin Madtom; Right: Margined Madtom.

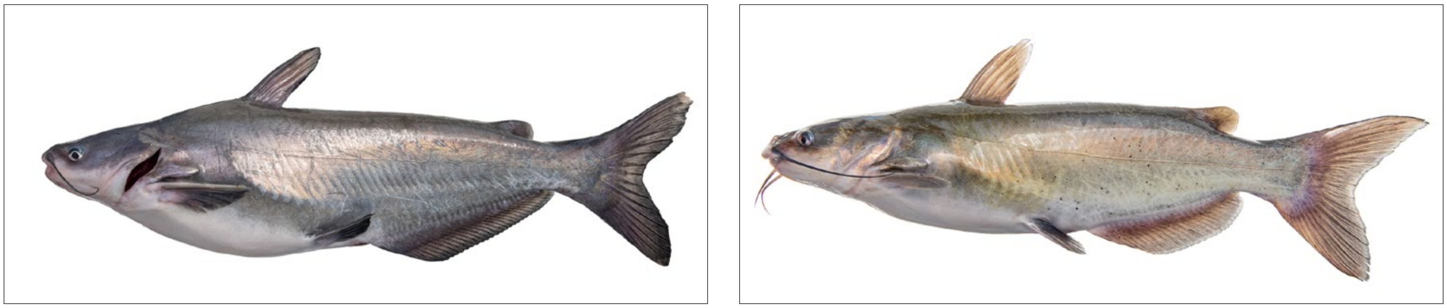

Figure 9. Left: Blue Catfish. Right: Channel Catfish.

8b. Caudal fin margin dusky or black, or if margin is pale, the pale portion is narrow and equal in width on upper and lower lobes (Figure 8). Caudal fin with dusky or black color equally developed on both lobes. Anal rays 15–21. Chin behind barbels weakly papillose. Range not restricted to the upper Dan River watershed in the Roanoke basin . . . .**Margined Madtom, *Noturus insignis***

9a. Premaxillary band of teeth with backward lateral extensions (Figure 2). Anal fin rays 12–16. Entire body mottled. Tip of dorsal lobe of caudal fin white except in very large specimens (Figure 12) . . . . **Flathead Catfish, *Pylodictis olivaris***

9b. Premaxillary band of teeth nearly straight, without backward lateral extensions. Anal fin rays 18–36. Entire body not mottled. Tip of dorsal lobe of caudal fin not white 10

10a. Caudal fin deeply forked (Figure 9) 11

10b. Caudal fin moderately forked, emarginate, or rounded 12

11a. Anal fin straight (Figure 9); anal fin rays (27)30–36 (38). Never spotted . . . . **Blue Catfish, *Ictalurus furcatus***

11b. Anal fin rounded (Figure 9); anal fin rays (23)25–30(32). Young to small adults with few to many dark spots . . . . **Channel Catfish, *Ictalurus punctatus***

12a. Dorsal fin with a dark basal blotch (Figure 10). Eye size moderate 13

12b. Dorsal fin without a dark basal blotch (Figure 10). Eye size small 14

13a. Chin barbels usually profusely pigmented (occasionally pigment only developed basally in small specimens) (Figure 11). Maxillary barbels uniformly dark. When viewed from the side, upper jaw with an extreme “overbite” (Figure 11). Premaxillary tooth patch in large juveniles and adults uniformly wide, lateral ends indented, and in adults, anterior teeth larger than posterior teeth (Figure 13). Anal rays usually 18–20 (18–22). (Figure 14) . . . . **Snail Bullhead, *Ameiurus brunneus***

13b. Chin barbels usually without pigment (pigment may be present in large specimens on lateral barbels, rarely on medial) (Figure 11). Leading edge of maxillary barbel pale, appearing bi-colored. When viewed from the side, upper jaw without an “overbite” (Figure 11). Premaxillary tooth patch in large juveniles and adults narrower medially, lateral ends not indented, and teeth of uniform size (Figure 13). Anal rays usually 22–24 (21–26). (Figure 14) . . . . **Flat Bullhead, *Ameiurus platycephalus***

14a. Caudal fin moderately forked or rounded. Chin barbels pale (Figure 15) 15

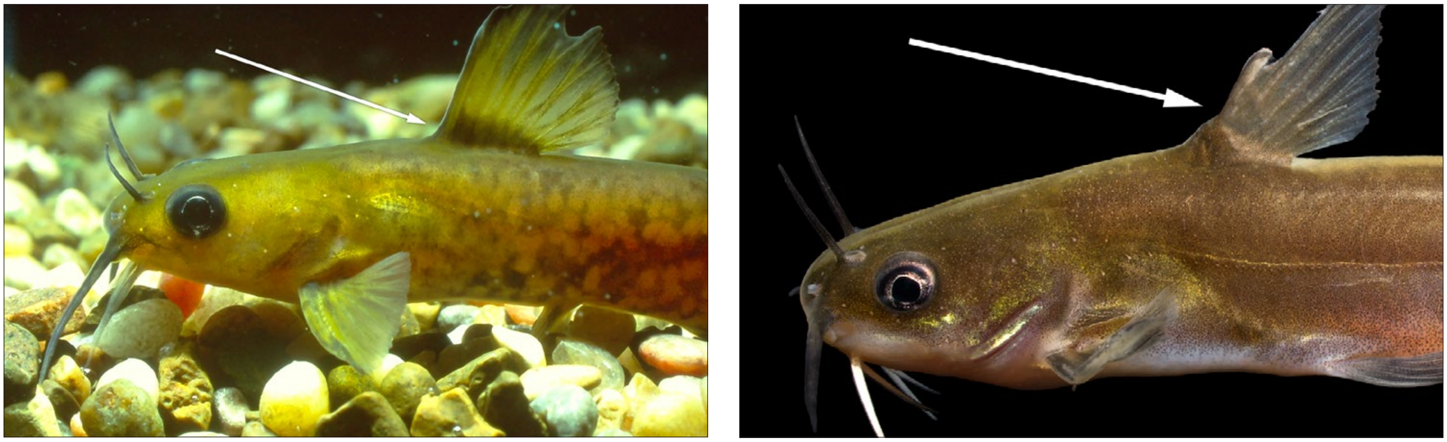

Figure 10. Left: Dorsal fin with dark basal blotch. Right: Dorsal fin without a dark basal blotch.

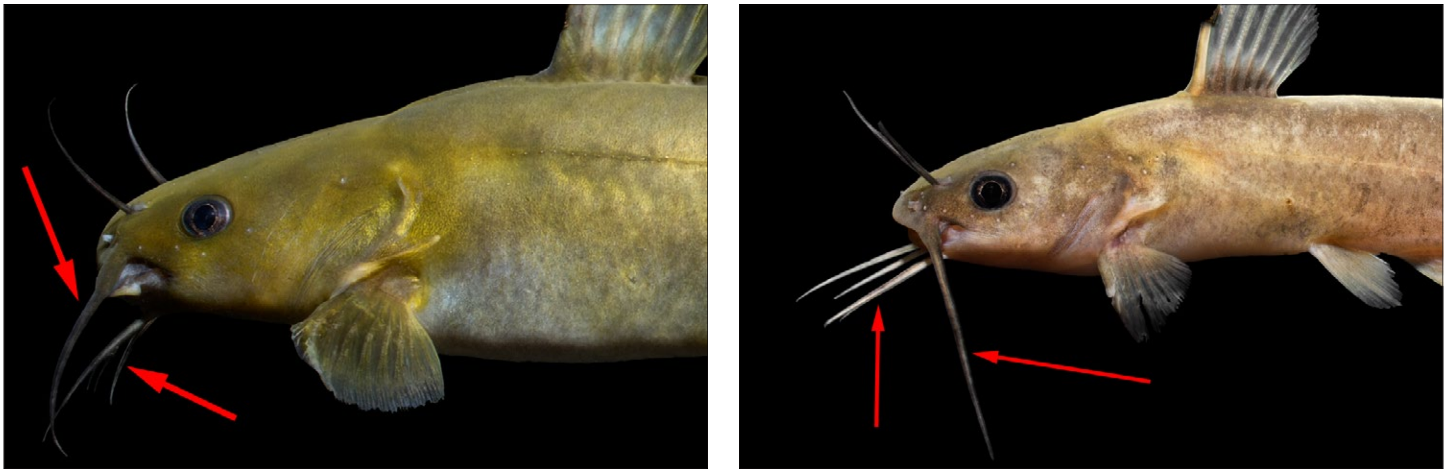

Figure 11. Left: Snail Bullhead with chin barbels usually profusely pigmented and maxillary barbels uniformly dark. Right: Flat Bullhead with chin barbels usually without pigment and leading edge of maxillary barbel pale, appearing bi-colored.

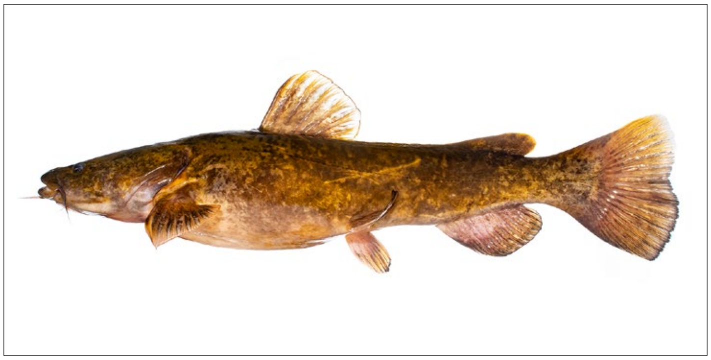

Figure 12. Flathead Catfish.

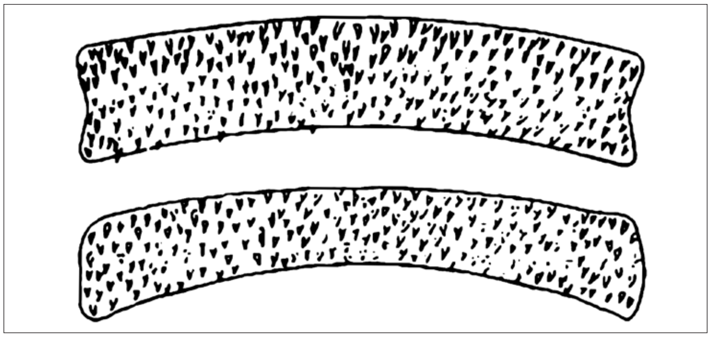

Figure 13. Top: Premaxillary tooth patch in Snail Bullhead. Bottom: Premaxillary tooth patch in Flat Bullhead.

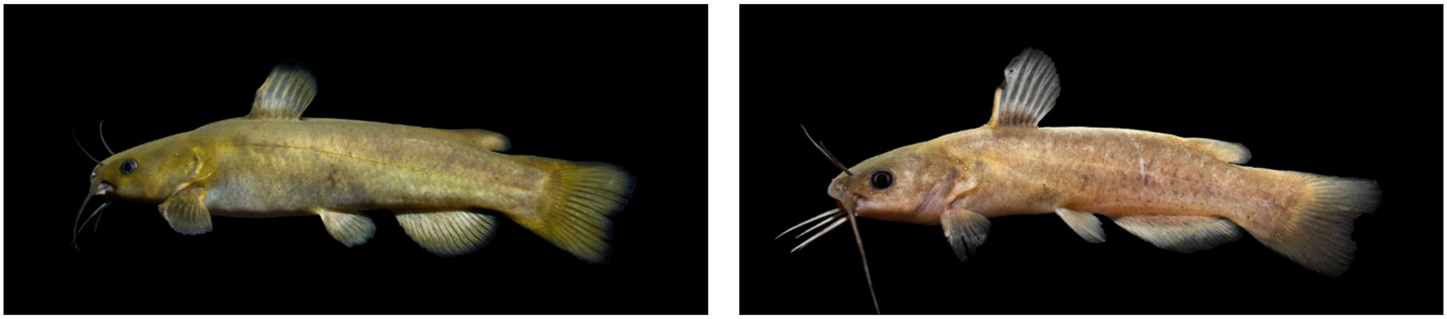

Figure 14. Left: Snail Bullhead. Right: Flat Bullhead.

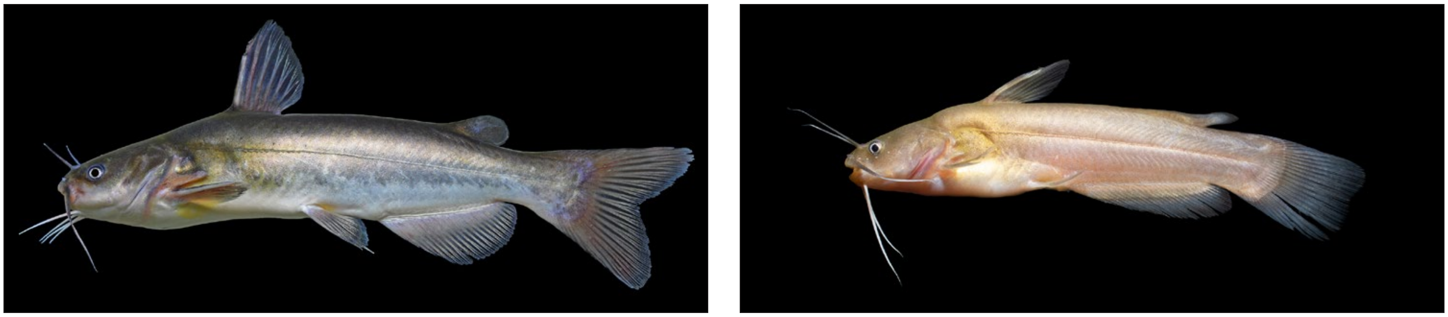

Figure 15. Left: White Catfish. Right: Yellow Bullhead.

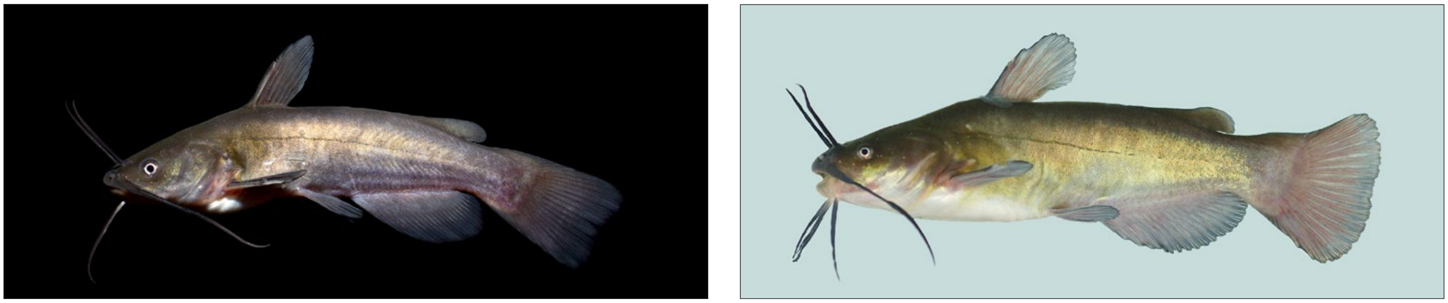

Figure 16. Left: Brown Bullhead. Right: Black Bullhead.

14b. Caudal fin slightly emarginate. Chin barbels dark (Figure 16) 16

15a. Caudal fin moderately forked (Figure 15). Anal margin rounded; anal fin rays 22–24 (21–25). . . . . **White Catfish, *Ameiurus catus***

15b. Caudal fin rounded (Figure 15). Anal margin nearly truncate; anal fin rays 25–28 (23–29) . . . . **Yellow Bullhead, *Ameiurus natalis***

16a. Caudal fin base uniformly dusky or dark in large juveniles and adults (Figure 16). Body often mottled. Total gills rakers on first gill arch typically 13–15 . . . . **Brown Bullhead, *Ameiurus nebulosus***

16b. Caudal fin base with a rectangular pale area often present in large juveniles and adults (Figure 16). Body not mottled. Total gills rakers on first gill arch typically 17–29. . . . . **Black Bullhead, *Ameiurus melas***

Table 3. Species of catfishes found in North Carolina listed by river basin in which they occur.[1, 2] Common names enclosed within quotation marks (“”) are scientifically undescribed species. Table originally appeared in Tracy et al. (2020).

	Mountain								Piedmont							Coastal						
Scientific Name	HIW	LTN	Sav	PIG	FRB	NOL	WAT	NEW	BRD	CTB	YAD	CPF	NEU	TAR	ROA	CHO	ALB	WOK	SHL	WAC	LBR	Total No. of Basin Occurrences
Ameiurus brunneus	IB	IB	I		IB				I	I	I	I	I		IB						I	11
Ameiurus catus				IB	IB			IB	I	I	I	I	I	I	I	I	I	I	I	I	I	16
Ameiurus melas										NI	NI				NI							3
Ameiurus natalis	IB									I	I	I	I	I	I	I	I	I	I	I	I	13
Ameiurus nebulosus	I	I		I	I		IB	IB	I	I	I	I	I	I	I	I	I	I		I	I	18
Ameiurus platycephalus	IB	IB		IB	IB	IB	IB		I	I	I	I	I	I	I	I			I	I	I	17
Ictalurus furcatus[3]		I								NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	13
Ictalurus punctatus	I	I		I	I	I		I	IB	IB	IB	IB	IB	IB	IB	IB	IB			IB	IB	17
Noturus eleutherus					I																	1
Noturus flavus		I			I	I																3
Noturus furiosus													I	I								2
Noturus gilberti															I							1
Noturus gyrinus											I	I	I	I	I	I	I	I	I	I	I	11
Noturus insignis			I				IB	IB	I	I	I	I	I	I	I	I	I	I	I	I	I	16
Noturus sp. “Cape Fear Broadtail” Madtom												I										1
Noturus sp. “Lake Waccamaw Broadtail” Madtom																				I		1
Noturus sp. “Pee Dee Broadtail” Madtom																				I	I	2
Pylodictis olivaris	I	I		I	I	I		I	IB	IB	IB	IB	IB	IB	IB			IB		IB	IB	16

	HIW	LTN	Sav	PIG	FRB	NOL	WAT	NEW	BRD	CTB	YAD	CPF	NEU	TAR	ROA	CHO	ALB	WOK	SHL	WAC	LBR	Total No. of Basin Occurrences
Total Number of Species	6	7	2	5	8	4	3	5	7	10	11	11	11	10	12	8	7	7	6	11	11	6
No. of Indigenous Species (= I + E)	3	5	2	3	5	3	0	2	5	65	7	8	8	7	7	6	5	5	5	8	8	3
No. of Nonindigenous Species (IB + NI)	3	2	0	2	3	1	3	3	2	35	4	3	3	3	5	2	2	2	1	3	3	3

[1] I = Indigenous (native), IB = Indigenous but not in this basin, NI = NonIndigenous (introduced).

[2] River basin abbreviations are: HIW = Hiwassee, LTN = Little Tennessee, SAV = Savannah, PIG = Pigeon, FRB = French Broad, NOL = Nolichucky, WAT = Watauga, NEW = New, BRD = Broad, CTB = Catawba, YAD = Yadkin, CPF = Cape Fear, NEU = Neuse, TAR = Tar, ROA = Roanoke, CHO = Chowan, ALB = Albemarle Sound, WOK = White Oak, SHL = Shallotte, WAC = Waccamaw, and LBR = Lumber.

[3] Blue Catfish was recently documented in Fontana Reservoir in the Little Tennessee River basin in 2020 (Luke Etchison and Powell Wheeler, North Carolina Wildlife Resources Commission, pers. comm.)

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(Identification key was adapted from these references)

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FishMap.org

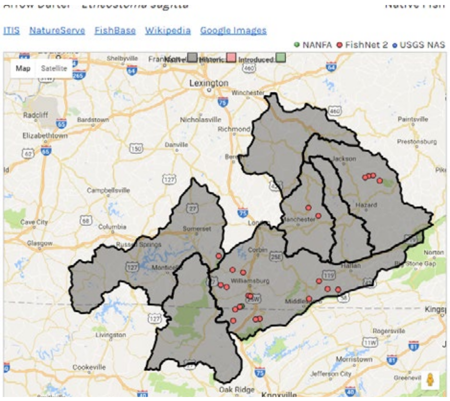
NORTH AMERICAN NATIVE FISHES ASSOCIATION

FishMap.org is for anglers, aquarium hobbyists, scientific researchers, or anyone else with a passion for fishes who wants to visually explore species' ranges or learn what species are in their local waters. The site is dedicated to spreading knowledge and respect for all fish species.

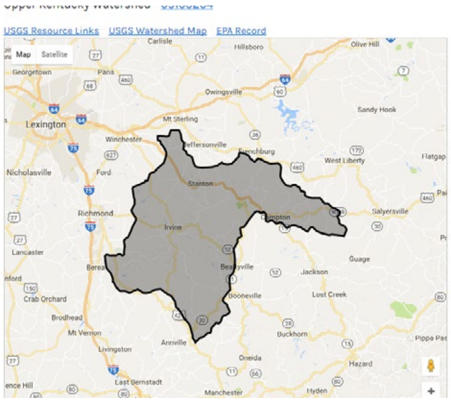
FishMap.org combines numerous data sources to provide a better view and more complete understanding of fish species distribution. It uses data from NatureServe, the National Atlas, the USGS water resources and Nonindigenous Aquatic Species programs, FishNet2, iNaturalist.org, GBIF, and iDigBio.

FishMap.org is sponsored by NANFA. Users can submit their own data to the portal to help map species distribution, so FishMap.org has been working with NANFA members to create an additional database of fish sightings and collections (currently nearly 30,000 records and growing).

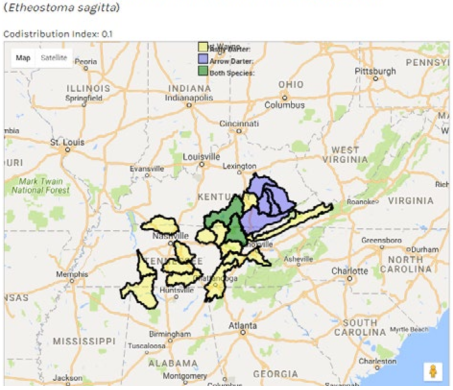
Range and Collection Data



Explore Watersheds



Compare Ranges



AMAZING AMERICAN EELS

Konrad Schmidt

Saint Paul, Minnesota

My first encounter with American Eels *Anguilla rostrata* was in June 1976 on the Mississippi River at US Lock and Dam 1 (Ramsey County, MN, Figure 1). I was an avid angler who fished the tailwaters of the dam with my high school buddies almost every day. The swift and swirling waters made the best fishing hole we had ever known for Smallmouth Bass *Micropterus dolomieu* and White Bass *Morone chrysops*. Almost every cast with spoon or spinner was rewarded with a scrappy and thrilling battle!

The first half of 1976 had been far behind in precipitation, and streams and rivers were unseasonably low. Weather forecasters were ominously predicting the worst drought since the Dust Bowl of the 1930s. Nevertheless, the water flowing over the dam's spillway was still too deep and swift to ever consider wading, and we fished safely from an island just a short distance downstream (Figure 1). That day, several barges locked through the dam. We never kept track of them but knew by the horn blasts that another barge was exiting a lock. Shortly after one horn blast, we noticed water coming over the spillway was rapidly diminishing and then ceased entirely. We hesitated, wondering how long this may last. One impatient buddy just couldn't wait: he waded chest deep in the now calm waters and walked triumphantly on the spillway. He immediately started holding up stranded fishes like trophies. The largest was our first ever Muskellunge *Esox masquinongy* weighing about 20 pounds. The temptation was too great for the rest of us to stay behind and we canoed over to the spillway. We fanned out, thrilled at what we might find next. Then someone stepped out of the powerhouse, and we feared are adventure was over. Instead, he smiled and waved us on. This was a different time, and I still marvel at what I used to do without concern of reprimand or arrest. We found more and more fishes. Of course, our original quarry of Smallmouth Bass and White Bass were everywhere, but there were also hog Common Carp *Cyprinus carpio* and Bigmouth Buffalo *Ictiobus cyprinellus*. I found my first Shortnose Gar *Lepisosteus platostomus* and was fascinated with its tooth-studded bill. Most of the fishes were able to escape on their own, flipping and flopping through a dense carpet of algae that covered the entire spillway. As the water continued to drain from the sponge-like algae, we noticed the concrete spillway was in very bad shape with extensive cracks everywhere. From one nearby crack, a slithering creature emerged and then another and another. It took us a little time to realize what they were. I think we all yelled in unison, "EELS!!!" We all charged in different directions trying to grab the one to two-foot "snakes." We all had aquariums and wanted to bring some home. Easier said than done! They could not outrun us, but the slimy devils could not be held or restrained. Like a pig greased with lard, we couldn't get any until finally realizing they could be aimed and "shot" short distances by squeezing them in our hands. I positioned the canoe where we had several corralled near the lip of the spillway. The first couple of tries didn't land any in the canoe, but after a little practice, we scored seven. We would have kept going, but the guy at the powerhouse yelled the water level had risen to the top of the dam and we should leave now. Sure enough, after we paddled back to the island, the spillway turned white again with raging waters. We did keep the eels and were

Photos by the author unless otherwise indicated.

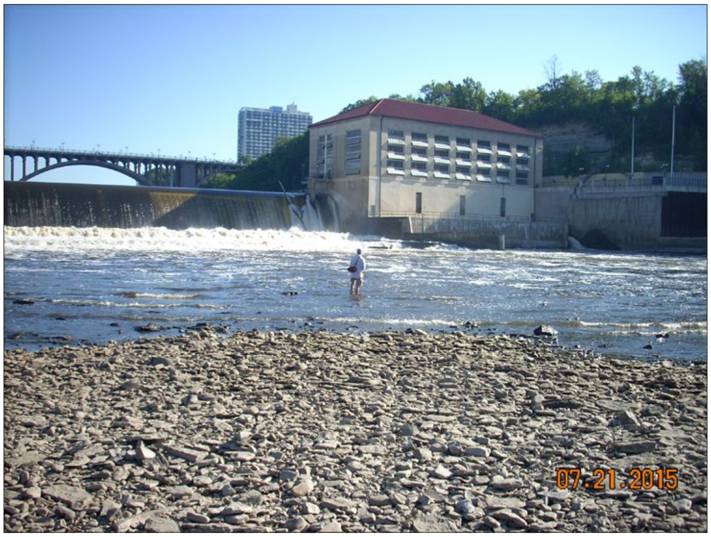


Figure 1. Smallmouth Bass angler fishing the tailwaters of US. Lock and Dam 1 at Saint Paul, MN.

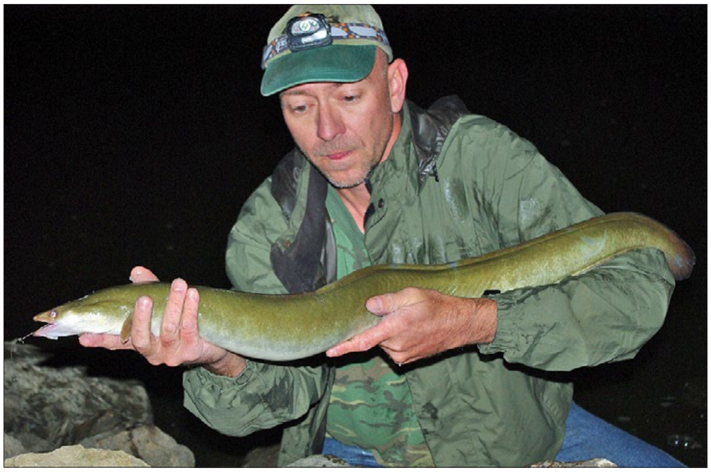


Figure 2. Corey Geving (Roughfish.com) struggles with a writhing American Eel for an almost perfect shot. The fish was caught in the Mississippi River at Hastings, MN on 16 August 2012. (Photo by Aaron Bye)

thrilled watching them burrow into the aquarium gravel to lay in wait when fed minnows. We also soon discovered these escape artists required full aquarium hoods weighted down with bricks!

I never saw American Eels in these numbers again but did catch them occasionally while fishing for Channel Catfish *Ictalurus punctatus* and Flathead Catfish *Pylodictis olivaris* at night (Figure 2). Sitting around campfires telling tall tales or nodding off, we were spooked countless times by what lurked in the dark depths when the bells erupted on our rod tips or when we heard the high-pitched squeal of line zinging out on old baitcaster reels. Once, my pole flew from its rod holder and splashed in the river. Leaping in after it, I groped in the darkness, found it, and set the hook with a hard yank. Fleeing eels always felt like whopper catfish until they turned around. Then in an instant, nothing, and I assumed the fish was lost. However, while reeling in the rest of the line, our flashlights revealed the fish was still on and zipping toward shore. I could not reel fast enough to keep the slack out! Finally, the lights exposed the eel writhing in the shallows. These catches always got the adrenaline pumping and kept us wide-eyed and alert anticipating more thrills to come.

I always credit my formative years of fishing and keeping native fishes as to why I chose a career as a fish biologist. However, my pursuit "evolved" from catching fish to studying species' distributions. Many Minnesota fishes have fascinating distributions, which are often attributed to Minnesota's most recent glacial history (Underhill 1989). However, American Eels in North America's interior waters, including Minnesota, are unique in being all females, and they are not permanent residents of the waters they occupy. They may live here for several years, but they are catadromous spawners that will eventually return to their natal Sargasso Sea in the North Atlantic to reproduce (Dybas 1990). The adults are assumed to all perish after spawning, but a new and incredible life cycle begins anew. The eel offspring ride ocean currents, which disperse them to river mouths from Greenland to Brazil. During the migration, American Eels undergo multiple metamorphoses. The early life stages include such striking transformations that early researchers believed they were different species. When the eels finally reach the end of their journey, whether it is a coastal water (males) or the upper reaches of a river or stream (females), American Eels remain there from three to sometimes more than 40 years before their return migration to the Sargasso Sea (USFWS 2011).

Minnesota lies on the periphery of the American Eel's range (Figure 3). This requires travel here by one of two routes: from the Gulf of Mexico up the Mississippi River to southeast Minnesota or from the Gulf of St. Lawrence through the Great Lakes to western Lake Superior. Both routes are long and arduous, but American Eels possess some legendary abilities that are vastly superior to those of most of their peers. Eels can survive at least 24 hours out of water without injury and will travel overland to bypass dams and falls (Eddy and Underhill 1976). There are also accounts of eels using tunnels and underground streams to reach their destinations. One closely related European Eel *A. anguilla* traveled 31 miles underground to reach a pond in Italy (Buffler and Dickson 1990). These super-fish feats may explain four very odd occurrences in Minnesota (numbers 1-4 in Figure 3), each of which are discussed in detail below.

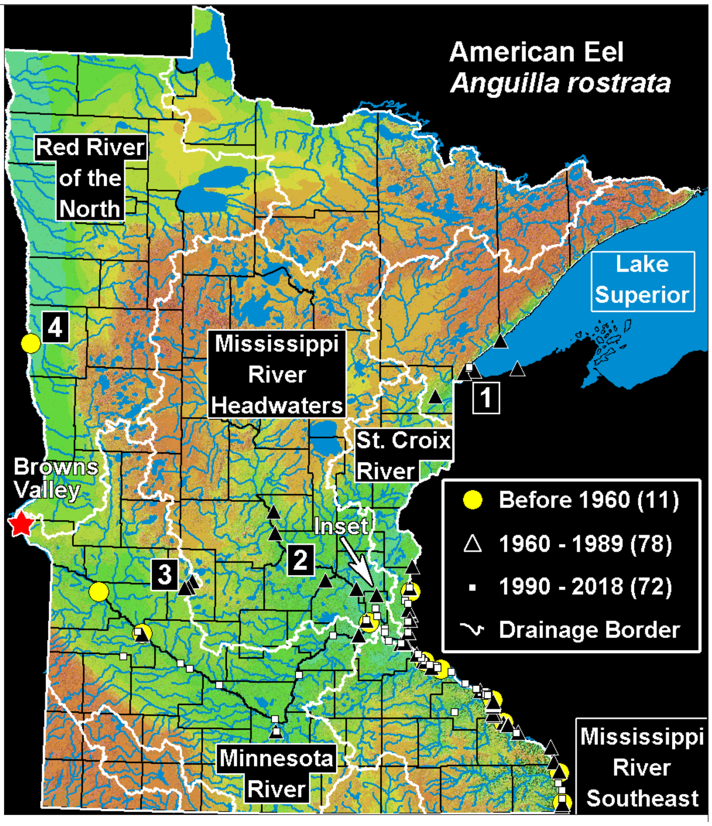


Figure 3. Distribution of American Eel in Minnesota major drainages. Numbers 1-4 are unusual occurrences reported in the following accounts. Figure 5 contains the inset map referenced above.

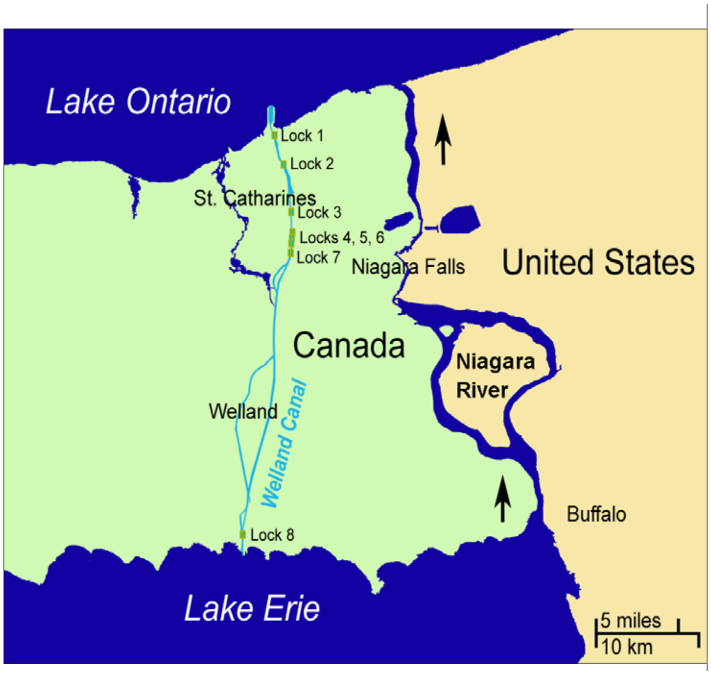


Figure 4. The Welland Canal that bypasses Niagara Falls. Arrows show direction of flow. Image released into the public domain.

LAKE SUPERIOR DRAINAGE - FIGURE 3, NO. 1: .

American Eels are not indigenous to the Great Lakes above Niagara Falls. However, the first known occurrence of American Eel from the Minnesota waters of Lake Superior was in 1966 (Eddy

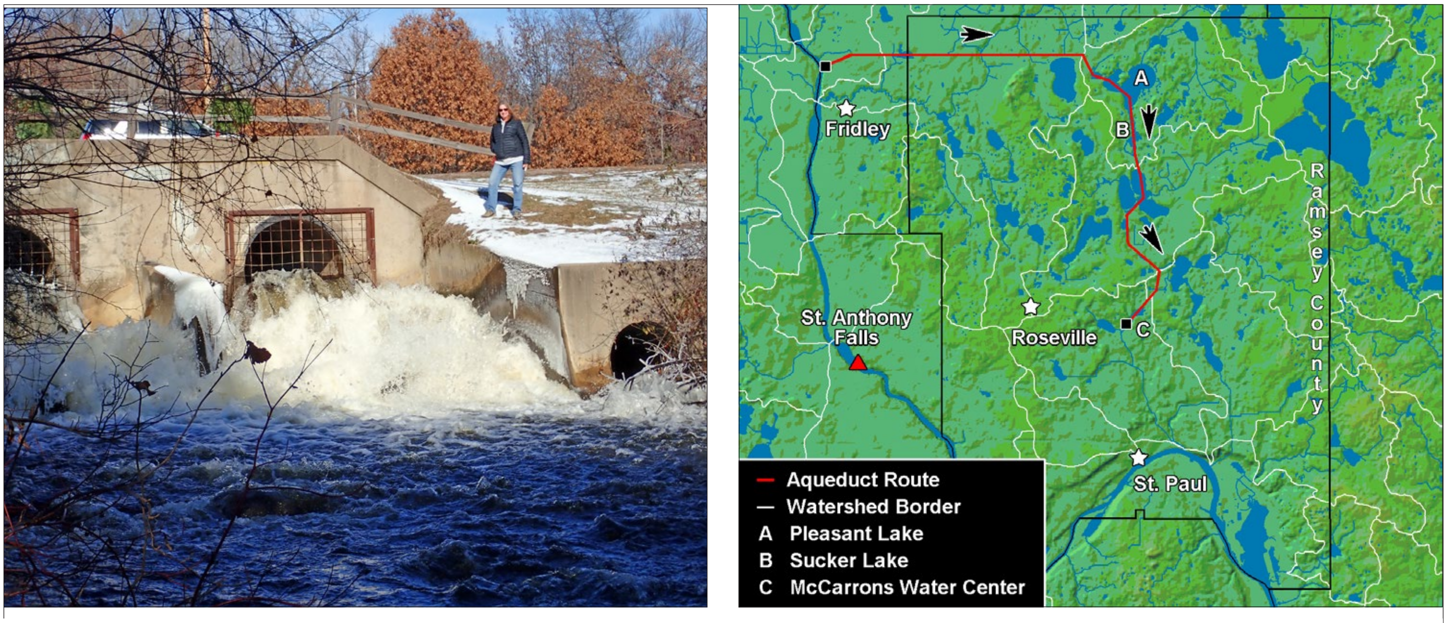


Figure 5. Left: NANFA member Jenny Kruckenberg at outfall of eight-mile aqueduct from the Mississippi River. Right: Detailed inset from Figure 3 of Saint Paul's water supply route from the Mississippi River.

and Underhill 1976). Most of the records reported since are clustered in the Duluth-Superior Harbor and St. Louis Bay, but also include single reports from the Bois Brule River mouth (Douglas County, WI) and the Knife River mouth (St. Louis County, MN). The late, great NANFA member Phil Cochran holds the record for finding the species furthest inland from Lake Superior (i.e., 24 air miles) in the Blackhoof River (Carlton County, MN). He was studying Northern Brook Lampreys *Ichthyomyzon fossor* in the Nemadji River system and assumed he had preserved only lamprey ammocoetes. He got a big surprise when he examined the collection back in the lab and found a small American Eel in the lot. One very good reason to preserve specimens! All these American Eels likely gained access through the Welland Canal, which was completed in 1829 but has since undergone several renovations and route changes (Wikipedia contributors). The current canal is 27 miles long and connects Lake Ontario and Lake Erie through a series of eight locks, allowing ships to bypass the 167-ft high Niagara Falls (Figure 4).

MISSISSIPPI RIVER HEADWATERS DRAINAGE - FIGURE 3, NO. 1.

For several millennia, a falls (later named St. Anthony after a missionary priest) posed a barrier to upstream fish migration on the Mississippi River at present-day Minneapolis. The differences in the historical fish faunas above and below the falls were striking before navigation locks were completed in 1963, with 64 species present above and 123 below the falls (Eddy et al. 1963). However, in 1960 at least one American Eel surmounted this ages-old (albeit human-altered) barrier and reached the northernmost extent ever reported in the Mississippi River at the outlet of Little Rock Lake (Benton County). This locality is 66 air miles north of the upper St. Anthony Falls Dam and required the fish to circumvent or scale four mainstem dams without locks or fish passage.

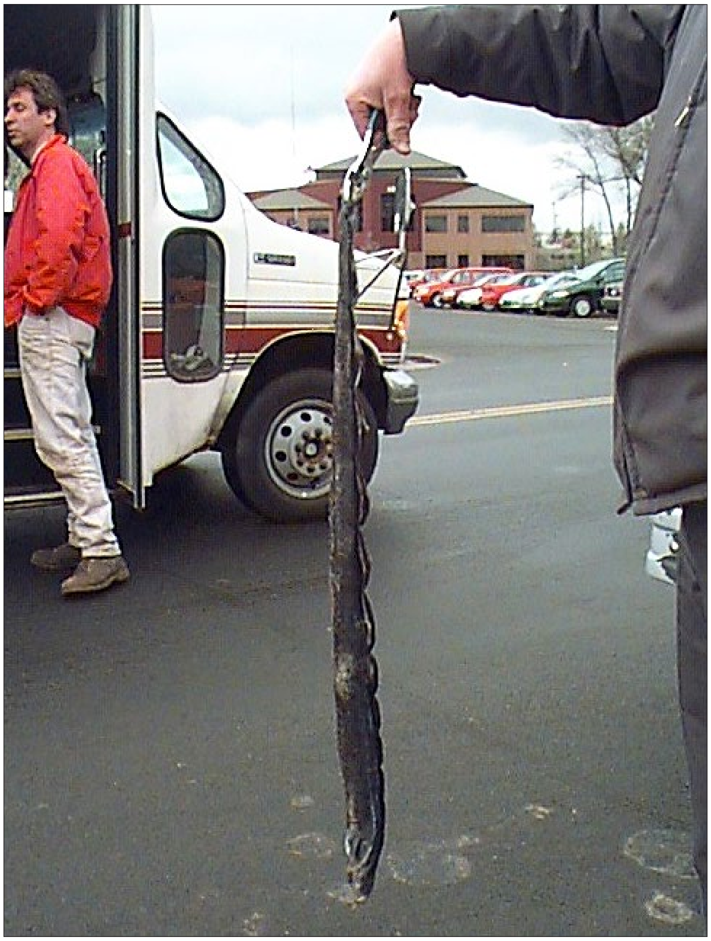
There are even more impressive accounts of at least three American Eels traveling through the plumbing of Saint Paul's water supply. The city's water source is a pumping station on the Mississippi River near Fridley, and the water flows through an eight-mile underground aqueduct (Figure 5). In 1984, an American Eel was collected in Pleasant Lake (Ramsey County). This lake has no natural inlets or outlets but lies in a lake chain (i.e., Charley, Pleasant, Sucker, and Vadnais) along the route to Saint Paul's McCarrons Water Center. In 1997, a dead eel was found in a malfunctioning pump that diverted water from Sucker Lake. This fish would have had to journey through another half-mile aqueduct from Pleasant Lake. However, the gold medal should be awarded (posthumously) to a fish (Figure 6) that made it all the way to the McCarrons Water Center. This marathon swimmer would have to pass through another pumping station on Vadnais Lake and travel through four miles of aqueduct to the water treatment plant. All in all, the eel covered 16 linear miles from the Mississippi River.

MINNESOTA RIVER DRAINAGE - FIGURE 3, NO. 3.

In Minnesota, American Eels generally have not been found in small tributaries great distances upstream of their confluences with large rivers. One exception is a chain of lakes near Willmar in Kandiyohi County. In 1988, a Minnesota Department of Natural Resources (MDNR) lake survey crew collected one American Eel in Eagle Lake which is the headwaters of Hawk Creek and 37 air miles from the Minnesota River. MDNR also reported additional eels were collected in the late1980s downstream of Eagle Lake in Willmar and Foot lakes for county fair exhibit aquaria.

RED RIVER OF THE NORTH DRAINAGE - FIGURE 3, NO. 4.

This occurrence, if true, would be the only record from the Hudson Bay basin. There are no photos or extant specimens. Dr. John Pterka (retired professor North Dakota State University) reported this occurrence with reservation since it was based on an interview he had with an angler about the angler's strange catch from the Red River at Fargo, ND in the 1950s. It would be difficult, but not impossible, to confuse American Eels with other species. Nevertheless, this fish would have had to ascend the Minnesota River



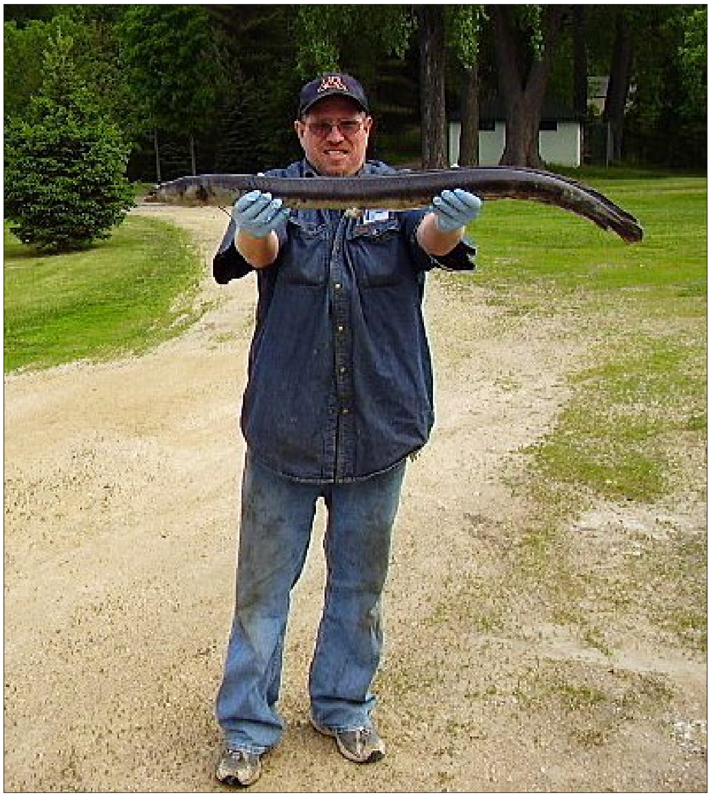


Figure 6. American Eels. Top: from Sucker Lake, MN (20 May 1997). Bottom: from McCarrons Water Center, Saint Paul, MN (28 May 2008). (Photo credit N/A)

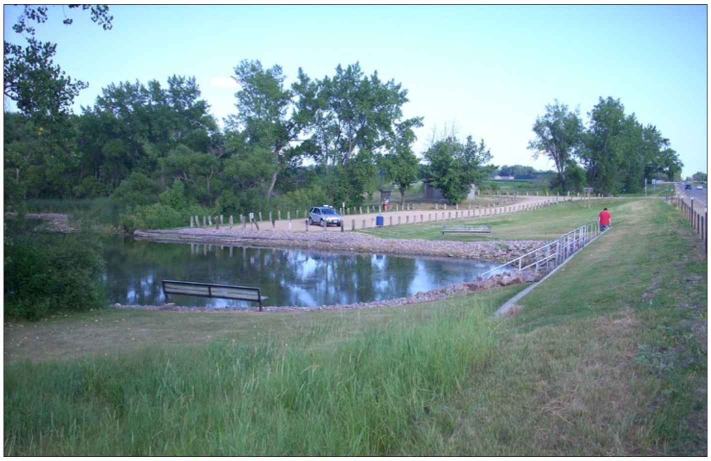


Figure 7. Fish passable road culvert at the head of Lake Traverse on the continental divide near Browns Valley, MN. Left side of road is in the headwaters of the Red River of the North which flows to Hudson Bay; right side is in the headwaters of the Minnesota River which flows to the Gulf of Mexico.

and cross the Laurentian continental divide near Browns Valley, MN, to access the headwaters of Red River. This feat is not impossible since water can flow to either the Red River or the Minnesota River drainages through a road culvert depending which drainage has a higher water level (Figure 7). White Bass *Morone chrysops* and Orangespotted Sunfish *Lepomis humilis*, which are not indigenous to the Red River of North drainage and were first reported in Lake Traverse, likely crossed at this point.

EPILOGUE

The MDNR has designated the American Eel a species of Special Concern because Minnesota is on the periphery of its range and appears to be declining regionally in abundance and distribution. USFWS recently reviewed the species and found it does not warrant protection at this time under the Endangered Species Act. My hope is this evolutionary marvel and cunning creature will continue to "visit" Minnesota for a very long time to come.

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RIFFLES

I know the photo is missing. Working on it. Olaf

DesPlaines River, Riverside, IL. (Olaf Nelson)

NOTES ON CAPTIVE HUSBANDRY, BIOLOGY, CONSERVATION, NOMENCLATURE, AND RECENT PUBLICATIONS

Compiled by Konrad Schmidt

This is the last Riffles with Konrad Schmidt at the helm. Please send fish-related links, publications, press releases, upcoming meetings and events, fish trivia, etc., to Bob Hrabik, who will begin wielding his mighty pen for the fall issue. His email is roberthrabik@gmail.com.

CHEMICAL CLOAKING MAY ENABLE FISH TO HIDE FROM PREDATORS AND PREY

Pirate Perch *Aphredoderus sayanus*

Pirate Perch are voracious predators of small amphibians, fishes, and invertebrates. The key to the species' feeding success is suspected to be a cloaking mechanism not yet fully understood. It may be a chemical secreted masking their presence to prey or maybe the Pirate Perch uses mimicry to avoid detection. More research is needed including if Pirate Perch can also mask themselves from their predators.

https://www.livescience.com/28334-fish-uses-chemical-cloaking-to-hide-from-prey.html

PLACE YOUR BETS ON THE LITTLE GUY

Sheepshead Swordtail *Xiphophorus birchmanni*

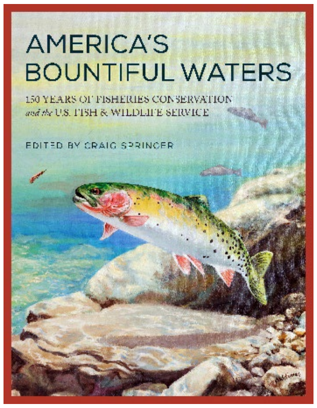
When they are feeding, smaller and usually male Sheepshead Swordtails exhibit aggressive behavior that kept larger and less aggressive competitors at bay. Researchers wondered if they were witnessing a case of Napoleon Complex, or smal-man syndrome, in fish. This trait may be crucial to survival of the Sheepshead Swordtail when food is scarce. Further research of this trait is needed to determine how it applies to the species' breeding success and its inherited personality traits.

https://www.livescience.com/29298-fish-fights-aggressive-personality.html

US FISH AND WILDLIFE SERVICE PUBLISHES A HISTORY OF THE AGENCY'S PROJECTS IN AQUATIC CONSERVATION

Fish and Aquatic Conservation (FAC) in the US Fish & Wildlife Service is the direct descendant of the US Fish Commission, founded in 1871. In 2021, FAC marks its 150th anniversary, the oldest conservation agency in history. To commemorate this milestone, USFWS will publish a compelling history to celebrate the broad-thinking scientists, writers, and artists who led us through the gilded age of American ichthyology into the present day.

You will read stories about fish—trout, bass, salmon, pike, muskie—and a few you have never heard of, all crafted by the USFWS biologists who know them best. America's Bountiful Waters is biography, evocative memoir, natural history, and human history supported by fresh dramatic photography and compelling historic images from the National Fish and Aquatic Conservation Archives. Joe Tomelleri provided the illustrations. The hardcover book can be pre-ordered from Amazon for $49.95.


AMERICA'S BOUNTIFUL WATERS
150 YEARS OF FISHERIES CONSERVATION and the U.S. FISH & WILDLIFE SERVICE
EDITED BY CRAIG SPRINGER

THE EYES HAVE IT.

Researchers have found the eye lenses of fishes record a fish's life history and diet. Like tree rings, lenses are archival and grow in layers. They record chemical signatures from habitats and what was consumed while a fish was there. A study of Chinook Salmon *Oncorhynchus tshawytscha* in California's Central Valley determined that an important freshwater habitat used during its life history was floodplains where the species exhibited the most rapid growth.

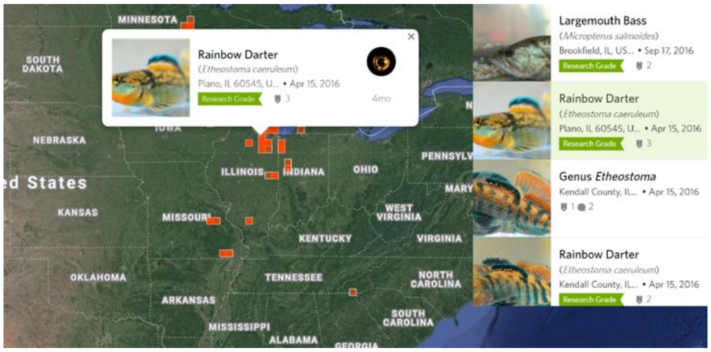
https://www.eurekalert.org/pub_releases/2021-01/uoc--erl012521.php

GREENIE THE GREEN SUNFISH

On an undisclosed lake in Minnesota, a woman and a sunfish have a unique bond. A five-year friendship is renewed every spring when Greenie returns to Holly Jorgensen's dock following ice-out. She hand-feeds the sunfish and it follows her over to the other side of the lake on daily swims. Once, Holly was mortified at Greenie's mealtime to see a hook in its mouth and she carefully removed it. Both were very relieved after the procedure. When asked how she knows it's the same fish all these years, Holly says she just knows. The YouTube video is truly a joy to watch!

https://www.youtube.com/watch?v=y4Voft1i1lk

INATURALIST: A COMMUNITY OF NATURALISTS



Rainbow Darter
(*Etheostoma caeruleum*)
Plano, IL 60545, U... • Apr 15, 2016
Research Grade 3

Largemouth Bass
(*Micropterus salmoides*)
Brookfield, IL, US... • Sep 17, 2016
Research Grade 2

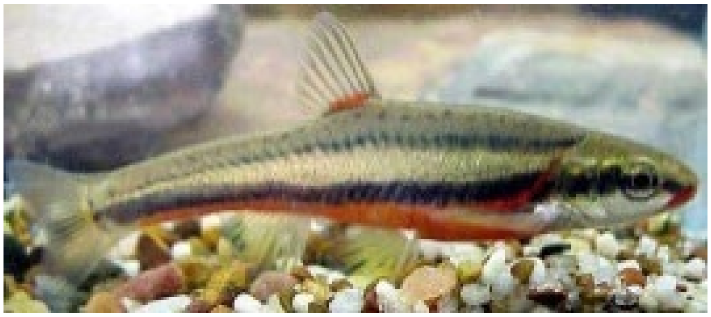
Rainbow Darter
(*Etheostoma caeruleum*)
Plano, IL 60545, U... • Apr 15, 2016
Research Grade 3

Genus *Etheostoma*
Kendall County, IL... • Apr 15, 2016
1 2

Rainbow Darter
(*Etheostoma caeruleum*)
Kendall County, IL... • Apr 15, 2016
Research Grade 2

iNaturalist is a social network of naturalists, citizen scientists, and biologists built on the concept of mapping and sharing observations of biodiversity across the globe. Every observation can contribute to science, from the rarest butterfly to the most common backyard weed. Many NANFA members are active on the site, but many others may wonder if the fishes they observe while collecting, snorkeling, or microfishing may be useful data. iNaturalist shares observational data with repositories where scientists can find and use the information. Almost 334,000 species have been observed, and over four million observers have made over 67 million observations so far. iNaturalist is a joint initiative of the California Academy of Sciences and the National Geographic Society. For more information, please visit: https://www.inaturalist.org/

LAUREL DACE GETS A LIFT FROM ROAD CULVERT REPAIR



Laurel Dace *Chrosomus saylori*

The Laurel Dace is found in only six streams flowing through Walden Ridge in central Tennessee where dense growths of Mountain Laurel line the stream banks. In 2011, the US Fish and Wildlife Service (USFWS) added the fish to the Endangered Species List. The species' decline was attributed to damaged and degraded road culverts that have created fish barriers. In 2017, the USFWS worked with the private forest management company which owns the land and replaced two undersized culverts with a single large arch design to provides fish passage for the Laurel Dace and other aquatic species.

https://www.fws.gov/southeast/articles/culvert-repair-partnership-in-tennessee-a-win-win-for-landowner-endangered-fish/

WORLD RECORD FALLFISH CAUGHT IN VIRGINIA

Jerry Hall of Rockbridge, Virginia, caught the new Virginia state record, and also world record, Fallfish *Semotilus corporalis* from the Cowpasture River on March 21, 2021. The fish weighed 3-lb, 5-oz. and measured 19 ¾ inches. The fish smashed the previous record holder by 13-oz. Learn more about Fallfish in the Virginia Department of Wildlife Resources blog: https://dwr.virginia.gov/blog/fallfish-little-tarpon-of-the-commonwealth/.

https://dwr.virginia.gov/blog/fallfish-little-tarpon-of-the-commonwealth/

Sunfish - Killifish - Minnows - Darters
Phone: (330) 417-9476
Email: smbass444@yahoo.com

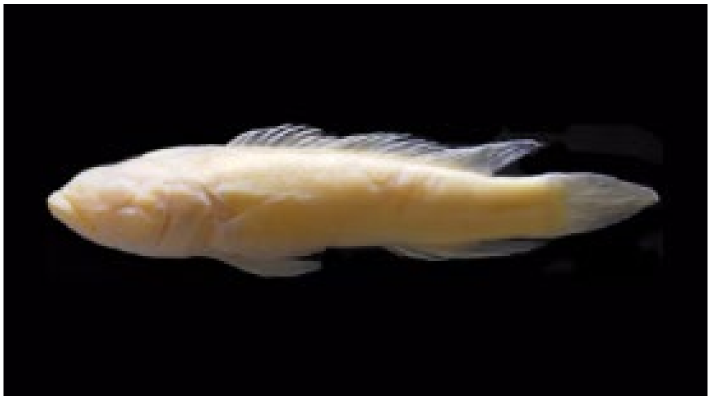
DEFEATING THE ENEMY WITHIN

Amazon Molly *Poecilia formosa*

The Amazon Molly—named for the female warrior tribe in Greek mythology—is an all-female species that reproduces asexually. Offspring are clones (exact genetic copies) of the mother. It is believed to have originated from a single female (i.e., the Prima Eva) that came from a hybrid cross between a female Atlantic Molly *P. mexicana* and a male Sailfin Molly *P. latipinna*. Clones typically do not evolve because their genes do not mutate, and lineages usually die out quickly because the genes of the heterosexual ancestors are in conflict. Amazons have been doing just fine for over 100,000 years, though, and research has shown they do exhibit genetic variation and are evolving. The species can regulate the two opposing genomes by using just one, thus preventing interference with evolution.

https://phys.org/news/2021-02-defeating-enemy-evolution-clone-fish.html

A DYING FISH REVEALS THE CONGO IS WORLD'S DEEPEST RIVER



Lamprologus lethops

The lowest 200 miles of Africa's Congo River are home to over 300 fish species. Rapids and submerged waterfalls form barriers in the river that divide fish populations, encourage speciation, and create the world's deepest river. A mystery surrounding a dying, depigmented blind cichlid in 2008 launched research leading to this discovery. The fish had died from the bends (i.e., decompression syndrome) when it was swept by swift currents from deep water to a shallow rapids. The bends can also be fatal to Scuba divers when they ascend too swiftly from great depths causing dissolved gases to form bubbles inside the body. Kayakers armed with sonar units and acoustic

NANFA's very own Snorkelmeister, Casper Cox, has written a snorkeling guide that is both useful (with maps and information about locations, access, biodiversity, identification, safety and more) and beautiul (with dozens of color photos by some of the best underwater photographers in the world). Written to complement the Freshwaters Illustrated film "Hidden Rivers," the book is a distillation of Casper's interests, experiences and skills, as well as a love letter to his favorite waters and their inhabitants.

75+ pages, lay-flat spiral binding, 3rd printing. $30 each

NANFA receives a donation for each copy sold through

http://www.nanfa.org/cart.shtml#guide

current profilers shot the rapids to measure depth and the direction and speed of current throughout the water column. The data revealed a maximum depth of 650 feet (200 meters) and powerful jet currents over the riverbed that could rapidly sweep a small fish to the surface.

https://www.livescience.com/congo-river-fish-with-bends.html

MISSOURI OZARKS PHOTO ARK PROJECT

Joel Sartore is a National Geographic Society photographer and author. His current project involves photographing fishes, mussels, and crayfishes of the Missouri Ozarks. However, he cannot devote any field time to collecting species himself and is requesting curators of public or private aquaria and hobby aquarists to inform him if they are maintaining any species from this region. He is willing to travel to photograph species where they are located. Bob Hrabik is making arrangements for Joel at a number of Missouri nature centers where some of the species he is looking for are kept. If someone is keeping Missouri Ozarks species, please contact Joel at joel.d.sartore@gmail.com or 402-326-1150.

See fish photos in the Photo Ark at https://www.nationalgeographic.org/projects/photo-ark/explore/?taxonomy_class=fish-ray-finned

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VERY OLD BIGMOUTH BUFFALO BENEFIT FROM RIVER RESTORATION EFFORTS

Bigmouth Buffalo *Ictiobus cyprinellus*

In 2019, North Dakota State University researchers found a Bigmouth Buffalo that was 112-years-old in the Pelican River of northwestern Minnesota. Their study also found several more over 80 years old in several lakes of the Pelican River system. However, an alarming discovery revealed there were no young fish in the population because of its isolation by dams. The last time spawning was observed in this population was in the 1930s before the dams were built. These Bigmouth Buffalo inhabit about 15-miles of river and cannot reach shallow lakes with submerged vegetation to spawn. Telemetry studies on the Red River of North in the US and Canada have found reproducing Bigmouth Buffalo occupy home ranges of 80-110 miles, and the longest distance traveled was 385 miles. Since 2018, three dams have been modified to provide fish passage, and efforts are underway to remove two more. This is good news for the imprisoned buffalo that will help immensely by reuniting them with other populations.

https://www.twincities.com/2021/01/16/minnesotas-oldest-fish-species-benefits-from-river-restoration-efforts/

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FISHES OF WISCONSIN POSTERS

The University of Wisconsin Zoological Museum has some amazing fish posters for sale. The 13-foot canvas poster shows all 183 species found in the state, at life size, and costs $150. Nine smaller posters, each depicting a subset (eight show families: the sunfishes, the pikes, the perches, the gars, the suckers, the salmonids, the catfishes, and the minnows; “The Little Fishes of Wisconsin” includes 16 families) are also available. The excellent art is by Kandis Elliot, UW-Senior Artist Emerita, and reference photos were provided by NANFA member John Lyons. See https://charge.wisc.edu/zoology/items.aspx for more info.

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DEDICATED TO THE APPRECIATION, STUDY AND CONSERVATION OF THE CONTINENT'S NATIVE FISHES

AN INVITATION TO JOIN OR RENEW

The North American Native Fishes Association is a 501(c)(3) not-for-profit, tax-exempt corporation that serves to bring together professional and amateur aquarists, anglers, fisheries biologists, ichthyologists, fish and wildlife officials, educators, and naturalists who share an interest in the conservation, study, and captive husbandry of North America's native fishes. A portion of each member's dues helps support three important initiatives: NANFA's Conservation Research Grant Program, which funds research on the biology and conservation of North America's most neglected and imperiled fishes; the Gerald C. Corcoran Education Grant, which funds educational outreach programs aimed at children and the general public; and the John Bondhus Conservation Grant, which supports organizations and groups working to conserve native fish populations.

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- ***AMERICAN CURRENTS,*** a quarterly publication featuring articles and news items on collecting, keeping, observing, conserving, and breeding North American fishes.
- **REGIONAL NANFA CHAPTERS.** State and regional aquarium groups where members may get together to collect and discuss native fishes, remove exotics, and perform conservation and stream restoration work.
- **NEW MEMBER PACKET.** An 8-page newsletter that's sent to new NANFA members introducing them to NANFA, and to the fascinating world of collecting, keeping and conserving North America's native fishes.
- **ANNUAL CONVENTION.** Where NANFA members from around the country meet for lectures, collecting trips, auctions, fun and finship. The 2021 convention will be held in Columbia, South Carolina, October 7–10.
- **GRANT FUNDING.** Only NANFA members can apply for NANFA's Conservation Research Grant and Gerald C. Corcoran Education Grant programs. For details, see NANFA's website (www.nanfa.org), or contact Dr. Bruce Lilyea, Conservation Grant Chair, 863-513-7611, bruce.lilyea@gmail.com, or Scott Schlueter, Education Grant Chair, scott_schlueter@hotmail.com.

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